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The Joint Forces of How to Live: Does Intellectual Capital Matter between Innovation and Financial Vulnerability?

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Abstract: Using a hand-collected sample of non-financial firms listed on the Pakistan Stock Exchange (PSX) over the period of 2011–2021, we examine the joint effect of intellectual capital and innovation on the financial vulnerability of a firm, which is an important risk factor that a firm may face in its operation. We first use the static fixed-effect panel model as our baseline regression model and find that the level of intellectual capital of a firm strengthens the positive effect of the adoption of product and market innovation on reducing the financial vulnerability of the firm. We also conduct additional analyses using alternative measures of financial vulnerability, as well as various regression models, and confirm that the results are robust under different scenarios. Overall, the results highlight the positive role of the intellectual capital, as well as the joint effect of intellectual capital and innovation, in mitigating the financial vulnerability faced by a firm and thus have academic and practical implications to academic researchers and practitioners.

Keywords: innovation; financial vulnerability; intellectual capital

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1. Introduction

Globalization has made the business world more efficient through the free flow of tangible and intangible capital, and it has accelerated the transition from the manufacturing process to the worldwide knowledge economy. The knowledge economy escalates dynamic and continuous value creation (Kallapur and Kwan 2004). The knowledge creation and integration increasingly help firms earn profits that are otherwise impossible to achieve with the sole use of tangible assets. As a result, it is commonly recognized that firm value in today's economy often resides on the intangible assets of a firm (Bontis 1998; Petty and Guthrie 2000). Nevertheless, the rapidly changing technology and the high competition have put pressure on firms to maximize their creativity and thus create a competitive business environment that steers the firms to develop new products and services (Ardito et al. 2020). Therefore, innovation is the driving force to obtain a beneficial influence on value creation and the future survival of a firm (Colombelli et al. 2016; Fernandes and Paunov 2015; Børing 2015; Howell 2015; Cefis and Marsili 2005, 2012; Fan and Lee 2012).

Modernization and innovation are powerful factors that influence the global economic trends and are inextricably intertwined (Akcigit et al. 2021). Firms that innovate can shift into a new paradigm to uncover new possibilities and the best solutions to present challenges (Cefis et al. 2020). Thus, firms that adopt a higher level of innovation often obtain a competitive advantage in the market that leads to a potential higher return for their business in the future (Bowen et al. 2010; Barrena-Martínez et al. 2020). Reversely, the lack of introduction of modern technology and innovation will put firms under financial challenges and vulnerability because without technology and innovation, firms have less elastic production and are less prepared to respond to the unpredicted shocks in the market (Umar et al. 2020; Cefis and Marsili 2005, 2012; Cefis et al. 2020). Resultantly, the unforeseen

shocks in the future lead to financial vulnerability that includes a sudden and unexpected loss of income and a sudden uncontrollable increase in expenditure. Therefore, to control for the potential financial vulnerability that the firms may face, they need to continuously engage in a higher level of innovative activities.

It is widely acknowledged that a firm's ability to innovate is intimately linked to its people resources, which in turn determines the firm's production (Li et al. 2019; Crescenzi and Gagliardi 2018). In this regard, intellectual capital has been demonstrated to have a significant effect on a firm's competitiveness and long-term stability (Aljuboori et al. 2021). The knowledge-based view considers the intellectual capital as an important source of superior performance for a firm (Barrena-Martínez et al. 2020; Tseng and Goo 2005; Subramaniam and Youndt 2005). In an era of a knowledge-based economy, knowledge-based human capital is the key to enabling firms to build value and gain a durable comparative edge (Ahmadi et al. 2012; Hitka et al. 2019). It drives a firm to continuously adapt to changes, to survive, and to eventually succeed in evolving the markets (Dwikat et al. 2023). Moreover, the creation of quota-free zones in the World Trade Organization environment now demands the industry to be more effective, resourceful, and knowledgeable (Muzam 2023). Intellectual capital thereby becomes more critical in assessing the productivity and financial output of the firm's management. The business climate has changed dramatically in that every industry is characterized by increasing their competitiveness, so businesses must adapt to this fierce competition by developing key competencies that were previously undervalued.

As both innovation and intellectual capital affect a firms' ability to be vulnerable to the financial problems and the stakeholders of a firm care about the firm's financial vulnerability, it is therefore important to understand how a firm manages the mechanism of creativity by leveraging human resources to monitor financial insecurity. Prior studies have attempted to explore this area. For example, a few studies attempt to contextualize the intellectual capital performance in the banking industry (Reed et al. 2006), intellectual capital and innovation in low- and high-tech industries (Buenechea-Elberdin et al. 2018), and the competitive role of intellectual capital in different regions (Tovstiga and Tulugurova 2009). Some studies discuss the intellectual capital, market turbulence, and business sustainability (De Clercq et al. 2018; Qiu et al. 2020). Some focus on small and medium enterprises (SMEs) in lieu of manufacturing concerns (e.g., Iqbal et al. 2021). Most studies adopt the intellectual capital as a bundle variable but ignore the separate and independent effects of each component (e.g., Han and Li 2015). Moreover, recent studies identify the positive role of intellectual capital in innovation ambidexterity through dynamic capabilities (Farzaneh et al. 2022), as well as exploring the incentive and selection effect of intellectual capital on innovation (Ren et al. 2022). Apart from those studies, the answer to the question about how different intellectual capital components shape the association between innovation and the financial vulnerability of a firm remain unknown.

This study attempts to fill in the gap by examining the moderating role of intellectual capital in the association between a firm's innovation and financial vulnerability in a developing country, like Pakistan. To do that, we first create three components of intellectual capital, human capital, structural capital, and employed capital efficiency, and the aggregate measure of the three individual components of intellectual capital, as well as two different proxies for innovation, market and product innovation, and then apply all the proxies to our empirical analysis. We use the static fixed-effect panel model as our baseline regression model to examine the effect of intellectual capital on the association between innovation and the financial vulnerability of non-financial sectors in Pakistan, and we find that the level of intellectual capital of a firm strengthens the positive effect of the adoption of product and market innovation on reducing the financial vulnerability of the firm. We also conduct additional analyses using alternative measures of financial vulnerability, as well as various regression models, and confirm the robustness of the results under different scenarios.

Our empirical evidence makes the following contribution to the literature. First, the study makes an important step in the existing empirical debate towards identifying the

association between financial vulnerability and innovation (Archibugi et al. 2013; Rajapathirana and Hui 2018; Ferreira et al. 2020; De Oliveira et al. 2018). Specifically, we find that the adoption of innovative activities can stabilize a firm's financial vulnerability, which is consistent with the findings from prior studies (Audretsch and Mahmood 1995; Cefis and Marsili 2005, 2012; Cefis et al. 2020). Additionally, we confirm the moderating role of intellectual capital in the association between innovation and the financial vulnerability of a firm, and the result thus highlights the importance of enhancing the intellectual capital for a firm. Specifically, corporate managers should improve the level of intellectual capital and undertake more innovative activities to mitigate the financial vulnerability of a firm or the potential risk of the unexpected loss of income and increase in expenditures due to sudden financial shocks. As the intellectual capital is one type of intangible asset of a firm, our empirical evidence also implies a positive role of an intangible asset in mitigating the financial vulnerability faced by a firm. Furthermore, our results have practical implications for the market participants, such as analysts and investors. Specifically, when market participants evaluate the firm value (e.g., use current data to forecast future sales and the operating performance of a firm), as well as assessing the probability of the survivorship of the firm, they need to take into consideration the firms' adoption of innovative activities (e.g., technology), as well as the intellectual capital within the firms, to operate.

We organize the subsequent sections of the study in the following manner: Section 2 reviews the literature and develops the hypotheses; Section 3 introduces the method to construct the sample and conduct research, as well as the key variables used in the study; Section 4 reports the empirical results; Section 5 discusses the empirical results; and Section 6 concludes.

2. Literature Review

2.1. Intellectual Capital and Financial Vulnerability

Intellectual capital is disaggregated in various key resources, such as human capital, structural capital, and relational/social capital (Subramaniam and Youndt 2005; McDowell et al. 2018; Reed et al. 2006; Barrena-Martínez et al. 2020). Human capital represents the skills, knowledge, and experience possessed by the employee; structural capital is defined as the culture, structure, and arrangement that facilitate the knowledge flow throughout the organization; relational/social capital captures the people's network and groups with whom the firms have built the relationships (Crupi et al. 2021).

Intellectual capital is a vital and important ingredient for the success of a firm in a vulnerable and competitive environment (Beltramino et al. 2021; Alqershi et al. 2022; McDowell et al. 2018; Edvinsson 1997). To some extent, it is more important than physical assets for the value creation of a firm (Bayraktaroglu et al. 2019; Khalique et al. 2018; Barpanda and Bontis 2021). A firm can use intellectual capital to improve its operating performance and to create value (Striukova et al. 2008). Intellectual capital can also assist a firm in obtaining the competitive advantage that enhances the growth sustainability (Massaro et al. 2020). Firms that possess superior intellectual capital can illicitly boost and motivate the employees to improve financial sustainability (Alvino et al. 2021; Ciambotti et al. 2021). Extant literature also provides evidence that intellectual capital extensively and positively influences the business sustainability (Gross-Gołacka et al. 2020) in manufacturing and service sectors (Xu and Wang 2018). Moreover, the higher level of intellectual capital helps to reduce the financial risk of a firm (Ozkan et al. 2017).

Overall, existing theories suggest that intellectual capital helps to improve the operating performance and reduce the financial risk of a firm and thus helps to mitigate the financial vulnerability faced by the firm, and the empirical evidence supports this conjecture from the theories (Kalkan et al. 2014; Sun et al. 2020; Anderloni et al. 2012; Ren and Song 2021; Poh et al. 2018).

2.2. Intellectual Capital and Innovation

Intellectual capital contributes positively to a firm's innovative activities (Subramaniam and Youndt 2005; Reed et al. 2006; Kianto et al. 2017; Barrena-Martínez et al. 2020; McDowell et al. 2018). For example, human and structural capital provides a foundation to generate new skills and ideas for a firm's innovative activities and thus enhance a firm's ability to successfully innovate new products or service (Xie et al. 2018; Youndt and Snell 2004). Intellectual capital can also be viewed as the non-monetary source for firms that is utilized for innovation activities (Firer and Williams 2003; Lev and Zambon 2003). The strategic use of accumulated intellectual capital in a firm thus helps to foster the innovation of the firm (Chatenier et al. 2010). As a result, the knowledge embedded in a firm, along with the innovation activities utilized by the firm, help the firm to obtain a competitive advantage in the market (Massaro et al. 2020; Cabrilo et al. 2020).

Intellectual capital envisions the knowledge, competencies, skills, and innovation capability of a firm (Alqershi et al. 2019). Innovation is invariably a highly uncertain activity that requires considerable intellectual capital and financial resources (Malerba and Orsenigo 2000). Theoretically, the interconnectedness of intellectual capital resources has a positive and direct impact on innovation performance (Buenechea-Elberdin 2017; Kianto et al. 2017; Wu et al. 2008; Pinar et al. 2019). The extant literature has also documented a significantly positive association between intellectual capital and innovation (Farzaneh et al. 2022; Kalkan et al. 2014). High intellectual capital helps a firm to undertake more innovation and to introduce new products to the market, which in turn increases the financial performance and reduces the financial risk of the firm (Örnek and Ayas 2015; Bchini 2015; Hashim et al. 2015; Delgado-Verde et al. 2016; Kianto et al. 2017; Ren and Song 2021; Tarus and Sitienei 2015; Pinar et al. 2019; Rezende et al. 2017; Liu 2017; Kianto et al. 2017). Intellectual capital can also help to improve the operation efficiency of a firm through innovation (Zhang et al. 2019).

2.3. Innovation and Financial Vulnerability

Innovation is important for a firm to sustain its performance in the market (Ferreira et al. 2020). Innovation stimulates the use of technology, and the use of technology will in turn improve the performance and decrease the financial distress of the firm (Cefis and Marsili 2005, 2012; Fernandes and Paunov 2015; Audretsch and Mahmood 1995). Generally, innovative firms with an onset of a crisis and financial vulnerability charge the innovation premium in terms of survival (Cefis et al. 2020). It brings a beneficial influence on the firms' survival (Colombelli et al. 2016; Fernandes and Paunov 2015; Børing 2015; Howell 2015; Cefis and Marsili 2005, 2012). Product innovation has an indirect impact on the financial vulnerability of a firm and helps to decrease the financial distress faced by the firm (Tarus and Sitienei 2015; Cefis et al. 2020). Specifically, a highly innovative firm can bring new products to the market that increase customers' interest, and in turn, the customers' avail of the new products helps to increase earnings and decrease the financial distress (Giebel and Kraft 2020). Market innovation is also inversely related to financial development in terms of financial vulnerability (Umar et al. 2020). The empirical evidence above suggests a positive impact of innovation on reducing the financial vulnerability of a firm (Lartey et al. 2020; Andries et al. 2019; Bernier and Plouffe 2019; Cefis et al. 2020). Innovative firms thus face less financial vulnerability. A firm can undertake more innovative activities to achieve a better operational performance (Woodward 2009). The implementation of innovation strategies can also lead a firm to have more financial gains (Nybakk and Jenssen 2012; Damanpour and Evan 1984; Thornhill 2006). Overall, the increase in the innovative activities utilized by a firm leads to the better operational and financial performance of the firm and thus decreases the financial vulnerability and financial risk faced by the firm. Contrary to these results, some studies conclude that innovation capabilities and innovation efforts can increase a firm's financial vulnerability (Rajapathirana and Hui 2018; Ferreira et al. 2020; De Oliveira et al. 2018).

According to the studies, it is risky and expensive to expose a firm to high costs and market fluctuations, leading to potential negative firm performance.

Overall, through the discussion above, we conclude that both the level of intellectual capital and innovation of a firm can help to reduce the financial vulnerability of the firm and that the intellectual capital of a firm can help to implement its innovative activities. It is thus reasonable to conclude that the level of intellectual capital can positively moderate the positive effect of innovation on reducing the financial vulnerability faced by a firm.

3. Sample Construction, Research Methodology, and Description of Key Variables

3.1. Sample Construction

From a total of 418 non-financial firms listed on the Pakistan Stock Exchange (PSX) over the period of 2011 to 2021, we targeted the ones that are continuously focusing on innovation and are maintaining efficient intellectual capital to construct our initial sample. After identifying the targeted firms, we hand-collected their financial data from the audited and published annual financial statements of the firms. We purposely excluded the financial and utility sectors due to the different regulatory requirements within the industries. We also excluded observations with missing values for the required variables used in the empirical analysis. Our final sample contains 2783 firm-year observations from 253 unique firms.[1]

3.2. Research Methodology

We followed the extant literature (Cameron and Miller 2015; MacKinnon et al. 2023; Anton and Nucu 2020; Tiwari 2022) and used the static panel model as our baseline regression model. To choose between the fixed-effect and the random-effect model, we performed the Hausman test, and the test result suggested the fixed-effect model for our empirical analysis. The fixed-effect model assumes that the independent variable is correlated with the individual firm specific and that the error is unrelated to all observations of the variable for the entity over time and has a zero conditional mean. Thus, the fixed-effect model allows us to better control for the firm heterogeneity in the empirical analysis.

To test the moderating effect of intellectual capital on the association between innovation and the financial vulnerability of a firm, we follow the extant literature (e.g., Ren et al. 2022) and regress the financial vulnerability of a firm in a year based on its innovation, intellectual capital, and the interaction term between the two items, along with some firm-level controls.[2] In each regression, we control for the firm and time fixed-effect. The variable of interest is the coefficient based on the interaction term between innovation and intellectual capital. The regression model is shown below, and Section 3.3. provides a detailed description on the key variables.

$$FV_{it} = \beta_0 + \beta_1 Innov_{it-1} + \beta_2 IC_{it-1} + \beta_3 Innov_{it-1} \times IC_{it-1} + \beta_4 FA_{it-1} + \beta_5 FS_{it-1} + \beta_6 EP_{it-1} + \beta_7 lev_{it-1} + \varepsilon_{it} \quad (1)$$

3.3. Description of Key Variables

3.3.1. Financial Vulnerability (FV)

In the regression model (1), FV represents the financial vulnerability of a firm in a year that is primarily measured by the equity ratio in the baseline model, and in the robustness tests, we also used the operating margin ratio, the administrative cost ratio, and the financial distress to proxy for the financial vulnerability faced by a firm (Tuckman and Chang 1991; Trussel 2002; Greenlee and Trussel 2000; Thomas and Trafford 2013; Altman 1968). Financial vulnerability is not the default but a difficult situation in debt payments due to negative shocks in the economy. The extant literature suggests that the indicators can well predict firms that are vulnerable to financial problems (e.g., Tuckman and Chang 1991; Altman 1968).

Equity Ratio (FV_{ER})

When facing the financial shock, firms with smaller equity balances are less able to replace the lost revenues than those with relatively larger amounts of equity. After the financial shock, firms possessing a high equity balance can leverage their assets, rather than the reduction in expenses, and thus have the ability to maintain their activities by selling the assets or by using them as collateral for loans (Tuckman and Chang 1992; Chang and Tuckman 1990). Hence, firms with a low equity balance are most likely to have high financial risks or high financial vulnerability (Tuckman and Chang 1991). The equity ratio is calculated as follows:

$$\text{Equity Ratio} = \frac{\text{Total Equity}}{\text{Total Revenue}}$$

Operating Margin Ratio (FV_{OM})

Firms with lower operating margins are more vulnerable to financial shocks in comparison to the ones with a higher operating margin. Firms experiencing the high operating margin can operate with a reduced operation margin during financial shocks/vulnerability and thus can make flexible future adjustments with the cutting of expenditures to maintain them for the subsequent year. Hence, a low operating margin indicates the high financial vulnerability of a firm. We follow (Tuckman and Chang 1991) and calculate the operating margin ratio as follows:

$$\text{Operating Margin} = \frac{\text{Total Revenue} - \text{Total Expenses}}{\text{Total Revenue}}$$

Administrative Cost Ratio (FVAC)

Firms with lower administrative cost ratios are more vulnerable to financial shock. After financial shock, firms with high administrative costs can notably reduce their discretionary administrative costs to maintain other expenditures and thus are flexible in their operations (Tuckman and Chang 1991). Hence, a low administrative cost ratio implies high financially vulnerability of a firm. We follow Tuckman and Chang (1991) and calculate the administrative cost ratio as follows:

$$\text{Administrative Cost Ratio} = \frac{\text{Admin Expenses}}{\text{Total Expenses}}$$

Financial Distress (FD)

The Altman Z score measures the likelihood of a firm to be bankrupt and can be used to capture the financial distress faced by a firm (Altman 1968). Firms facing more financial distress normally have higher financial vulnerability (Lagasio et al. 2023). Thus, we use the Altman (1968) Z-score as an additional measure of the financial vulnerability of a firm. A lower Altman Z score represents a higher probability of bankruptcy or more financial distress faced by a firm and thus indicates high financial vulnerability of a firm.[3] The discriminant function takes the following form, in which all the Xs are in percentage values:

$$Z = 0.012\ X_1 + 0.014\ X_2 + 0.033\ X_3 + 0.006\ X_4 + 0.999\ X_5$$

X_1 = Working capital/Total assets, X_2 = Retained Earnings/Total assets, X_3 = Earnings before interest and taxes/Total assets, X_4 = Market value of Equity/Book value of total debt, X_5 = Net sales/Total assets.

3.3.2. Innovation (Innov)

Innovation defines a firm's capability to formulate and integrate the effective and efficient existing resource allocation to match changing market requirements (Morgan et al. 2009). In this study, we used two proxies, market innovation (MI) and product innovation (PI), to capture the dynamic capabilities of a firm to innovate (Cefis et al. 2020).

Generally, market innovation is defined as firms' behavior of buying new media and techniques, changing the product packing, and introducing some new media in a company. Market innovation is the significantly improved methods, enabling firms to efficiently utilize resources in accordance with customer's demands and the creation of superior customer value (Ramadani et al. 2019; Wang et al. 2020). The novel and innovative marketing techniques are involved in significant variation in packaging, design, branding, and positioning. The factors in market innovation are innovative promotion and distributing schemes with an extraction of potential market demands (Lin et al. 2010) In this study, we defined market innovation (MI) as an indicator variable that equals 1 if a firm adds new media and techniques in product packing and buy new in a year, with 0 otherwise (Cefis et al. 2020).

Product innovation represents firms' launches of novel technological innovations, new methods of production, new product development, and the addition of new elements in the product (Mohan et al. 2021). It is the innovation of products, processes, and services in a novel way (Krammer and Jimenez 2020). In this study, we define product innovation (PI) as an indicator variable that equals 1 if a firm is involved in product innovation (technological innovation, new product development, and the addition of new elements in the product) in a year, with 0 otherwise (Ozer and Zhang 2015; Cefis et al. 2020).

3.3.3. Intellectual Capital (IC)

In this study, we measured intellectual capital (IC) as human capital efficiency (HCE), structural capital efficiency (SCE), capital employed efficiency (CEE), and the aggregate measure of the three items: value-added intellectual capital (VAIC) (Pulic 2000; Bontis 1998; Hayaeian et al. 2022; Oppong and Pattanayak 2019; Xu et al. 2019). Specifically, we followed the extant literature (e.g., Pulic 2000; Farooq et al. 2022) and used the VAIC model to calculate the proxies of intellectual capital used in the study as follows:

$$\text{VAIC} = \text{f}(\text{HCE}, \text{SCE}, \text{CEE}) \tag{2}$$

$$\text{VA} = \text{OUT} - \text{IN} \tag{3}$$

$$\text{HCE} = \frac{\text{VA}}{\text{HC}} \tag{4}$$

$$\text{SCE} = \frac{\text{VA} - \text{HC}}{\text{VA}} \tag{5}$$

$$\text{CEE} = \frac{\text{VA}}{\text{CE}} \tag{6}$$

The Equation (2) shows that the aggregate measure of intellectual capital (VAIC) is a function of three individual components of intellectual capital: human capital efficiency (HCE), structural capital efficiency (SCE), and capital employed efficiency (CEE). The value added (VA) in Equation (3) is the deduction of total expenditures (IN) from the net income (OUT). Human capital efficiency (HCE) in Equation (4) is the fraction between values added to human capital where human capital is the total expenditures based on employee development. Equation (5) shows the structural capital efficiency (SCE) that is the subtraction of human capital from value added (net value) to value added. The capital employed efficiency (CEE) in Equation (6) is the fraction between the relational capital and value added, where relational capital is the total selling expenses. It is worth noting that, to better capture and interpret the economic effect of intellectual capital on the association between innovation and financial vulnerability, we create indicator variables for each measure of the intellectual capital based on the median value of the measure.[4]

3.3.4. Control Variables

Age represents the firm age based on the number of years from firm establishment (Lenihan et al. 2019). FS stands for the firm size and is measured based on the natural log of total assets (Lenihan et al. 2019). EP is the economic performance of a firm based on

return on sales (Kou et al. 2020). Lev represents the financial leverage ratio of a firm that is measured by total debt over total assets (Kou et al. 2020).

Appendix A summarizes the definitions of the key variables used in the study.

4. Results and Discussions

4.1. Descriptive Statistics and Correlation Analysis

Table 1 reports the descriptive statistics of the key variables in the study.[5] Our primary measure of financial vulnerability, the equity ratio (FV_{ER}), has an average value of 0.6623, suggesting that the non-financial firms in Pakistan are maintaining 66.23% equity in relation to their revenues. The other measures of financial vulnerability, the operating margin ratio (FV_{OM}), the administrative cost ratio (FV_{AC}), and the financial distress (FD), have the mean values of 0.1305, 0.1928, and 1.8899, respectively. The two proxies for innovation, market innovation (MI) and product innovation (PI), have mean values close to 0.5, indicating that the numbers of observations with and without product and market innovation are about equal. The four proxies for intellectual capital, human capital efficiency (HCE), structural capital efficiency (SCE), capital employed efficiency (CEE), and value-added intellectual capital (VAIC), have mean values of 0.4860, 0.3681, 0.4941, and 0.4266, respectively, suggesting that the numbers of observations in the low intellectual capital group are slightly higher than the ones in the low intellectual capital group.

Table 1. Descriptive statistics.

Variables	Obs.	Means	Std. Deviation	P25	P50	P75
FV_{ER}	2783	0.6623	0.784	0.3421	0.6802	0.892
FV_{OM}	2783	0.1305	0.4416	0.068	0.1077	0.1698
FV_{AC}	2783	0.1928	0.621	0.0842	0.218	0.3338
FD	2783	1.8899	1.1734	0.8525	1.9081	2.6451
MI	2783	0.5157	0.4999	0	1	1
PI	2783	0.4852	0.5	0	0	1
HCE	2783	0.486	0.5	0	0	1
SCE	2783	0.3681	0.4825	0	0	1
CEE	2783	0.4941	0.5002	0	0	1
VAIC	2783	0.4266	0.4948	0	0	1
Age	2783	35.3663	15.3167	24	32	48
FS	2783	8.2261	1.3842	7.0979	8.5481	9.4265
EP	2783	0.1379	0.7016	0.0301	0.0717	0.1855
Lev	2783	0.4679	0.1621	0.3244	0.4547	0.61

Note: The above table represents the descriptive statistics of the variables. Both tails of distribution of variables were winsorized at the 1% and 99% level before the submission of descriptive statistics. Financial vulnerability was calculated in three different ways, like the FV_{ER} (Equity Ratio), FV_{LNOM} (Low or Negative Operating Margin Ratio), and FV_{AC} (Admin Cost Ratio). MI and PI are market innovation and product innovation, respectively. HCE is the human capital employed by the firms. SCE is the structural capital employed, while CEE is the customer capital employed, and VAIC is the value-added intellectual capital, which was measured using the value-added method. Age is the firm age, which was calculated based on the number of years from the firm's establishment. FS is the firm's size, and it was calculated based on the total assets the firm owns. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total assets). Lev is the financial ratio of a firm and was calculated based on the debt ratio (total debt divided by total assets).

Table 2 reports the result of the correlation analysis. As expected, several proxies for financial vulnerability (FV_{ER}, FV_{OM}, FV_{AC}, and FD) are positively correlated. Interestingly, all proxies for innovation (MI and PI) and intellectual capital (HCE, SCE, CEE, and VAIC) are also positively correlated, and they are also positively correlated with all the proxies for financial vulnerability. The correlation analysis provides us some initial evidence that both innovation and intellectual capital have a positive effect on reducing the financial vulnerability of a firm.[6] Thus, it is worth testing whether the joint effect between the two items will also positively affect the financial vulnerability of a firm.

Table 2. Correlation analysis.

Variables	FV_{ER}	FV_{OM}	FV_{ACR}	FD	MI	PI	HCE	SCE	CEE	VAIC	Age	FS	EP	Lev
FV_{ER}	1.000													
FV_{OM}	0.704	1.000												
FV_{AC}	0.721	0.593	1.000											
FD	0.014	0.017	0.002	1.000										
MI	0.027	0.005	0.009	0.010	1.000									
PI	0.001	0.030	0.008	0.024	0.047	1.000								
HCE	0.010	0.003	0.005	0.034	0.016	0.025	1.000							
SCE	0.130	0.122	0.105	0.051	0.004	0.005	0.146	1.000						
CEE	0.028	0.057	0.062	0.054	0.021	0.020	0.014	0.011	1.000					
VAIC	0.060	0.031	0.032	0.022	0.049	0.004	0.450	0.530	0.232	1.000				
Age	0.125	0.127	0.187	−0.005	0.051	0.023	0.015	0.151	0.020	0.104	1.000			
FS	0.112	0.063	0.156	−0.094	0.019	0.019	0.056	0.049	0.024	0.011	−0.178	1.000		
EP	0.366	0.326	0.322	−0.112	0.010	0.048	0.033	0.186	0.137	0.174	0.084	−0.150	1.000	
Lev	−0.082	0.082	−0.101	0.161	−0.012	−0.005	0.036	0.096	0.069	0.126	−0.088	0.130	−0.227	1.000

Note: The table represents the correlation matrix between the independent and dependent variables, moderator and control variables. It shows the direction of the relationship between variables. Financial vulnerability was measured using three different ways, FV_{ER} (Equity Ratio), FV_{LNOM} (Low or Negative Operating Margin Ratio), and FV_{AC} (Administrative Cost Ratio). Innovation represents the market innovation (MI) and product innovation (PI). HCE is the human capital employed, SCE is the structural capital employed and customer capital employed (CCE), while VAIC is the value-added intellectual capital, which was calculated based on the value added. Age is the firm age, which was calculated based on the number of years since the firm was established. FS is the firm size, and it was calculated based on the total asset's log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total assets). Lev is the financial ratio of a firm and was calculated based on the debt ratio (total debt divided by total assets).

4.2. Financial Vulnerability and Innovation: Role of Intellectual Capital

Table 3 reports the results for the role of intellectual capital in the association between the financial vulnerability and innovation (Market and Product) of the non-financial firms listed on the Pakistan Stock Exchange (PSX), in which the equity ratio (FV_{ER}) is used as the dependent variable to proxy for the financial vulnerability of a firm. In all columns of the table, the coefficients for innovation (Innov), including market innovation (MI) and product innovation (PI), are positive and statistically significant ($p < 0.01$). As a higher equity in relation to revenue means a lower financial risk or a lower financially vulnerability for a firm, the empirical evidence indicates that an increase in innovation is associated with a decrease in financial vulnerability, which is consistent with the findings from the extant literature (Lartey et al. 2020; Andries et al. 2019; Bernier and Plouffe 2019; Cefis et al. 2020). Similarly, the coefficients for human capital employed (HCE), structural capital employed (SCE), capital employed efficiency (CEE), and value-added intellectual capital (VAIC) are also positive and statistically significant ($p < 0.05$). The result suggests that an increase in intellectual capital is associated with a decrease in financial vulnerability, which is also consistent with the findings from the extant literature (Sun et al. 2020; Poh et al. 2018; Pinar et al. 2019). The coefficients for our variable of interest, the interaction terms between intellectual capital and innovation (Innov × IC), are also positive and statistically significant ($p < 0.01$). In addition, the marginal effect is economically significant. Set Column A as an example, the value for the equity ratio in the group with high intellectual capital and high innovation is about 2.7% higher than the value for the one in the other groups.[7] The result supports our conjecture in Section 2 that the intellectual capital of a firm can help to implement its innovative activities, thus leading to lower financial vulnerability of a firm (Anderloni et al. 2012; Lartey et al. 2020).

Table 3. Estimation results between innovation and financial vulnerability (equity ratios) with the role of intellectual capital.

Use the Equity Ratio (FV_{ER}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$Innov_{(t-1)}$	0.0411 ***	0.0665 ***	0.0226 ***	0.0270 ***	0.0146 ***	0.0199 ***	0.0840 ***	0.0426 ***
	(0.0112)	(0.0102)	(0.0093)	(0.0103)	(0.0059)	(0.0080)	(0.0115)	(0.0102)
$HCE_{(t-1)}$	0.0750 ***				0.0231 **			
	(0.0120)				(0.0109)			
$SCE_{(t-1)}$		0.0289 **				0.0371 ***		
		(0.0128)				(0.0116)		
$CEE_{(t-1)}$			0.0324 ***				0.0196 **	
			(0.0135)				(0.0095)	
$VAIC_{(t-1)}$				0.0234 **				0.0220 **
				(0.0120)				(0.0114)
$Innov_{(t-1)} \times HCE_{(t-1)}$	0.0181 ***				0.0383 ***			
	(0.0062)				(0.0154)			
$Innov_{(t-1)} \times SCE_{(t-1)}$		0.0285 ***				0.0750 ***		
		(0.0066)				(0.0133)		
$Innov_{(t-1)} \times CEE_{(t-1)}$			0.0591 ***				0.0758 ***	
			(0.0119)				(0.0120)	
$Innov_{(t-1)} \times VAIC_{(t-1)}$				0.0494 ***				0.0654 ***
				(0.0157)				(0.0155)
$Age_{(t-1)}$	0.0014 ***	0.0016 ***	0.0086 ***	0.0122 ***	0.0011 ***	0.0151 ***	0.0011 **	0.0012 ***
	(0.0005)	(0.0005)	(0.0022)	(0.0044)	(0.0004)	(0.0049)	(0.0006)	(0.0004)
$FS_{(t-1)}$	(0.0057)	(0.0043)	(0.0078)	(0.0548)	(0.0045)	(0.0049)	(0.0045)	(0.0050)
	(0.0046)	(0.0047)	(0.0070)	(0.0426)	(0.0043)	(0.0047)	(0.0055)	(0.0042)
$EP_{(t-1)}$	0.1400 ***	0.1179 ***	0.0725 **	0.1357 ***	0.1468 ***	0.1142 ***	0.1444 ***	0.1356 ***
	(0.0296)	(0.0314)	(0.0366)	(0.0288)	(0.0281)	(0.0301)	(0.0425)	(0.0286)
$Lev_{(t-1)}$	−0.0561 *	0.0128	−0.0816 **	(0.0320)	−0.0791 ***	−0.0615 *	(0.0412)	−0.0362
	(0.0325)	(0.0319)	(0.0391)	(0.0299)	(0.0303)	(0.0325)	(0.0376)	(0.0299)
Cons	0.0725 ***	0.0381	(0.1632)	0.0702	0.0865 **	0.0825 *	0.0546	0.0741 *
	(0.0047)	(0.0479)	(0.0992)	(0.0434)	(0.0435)	(0.0479)	(0.0481)	(0.0441)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.1616	0.1496	0.1564	0.1695	0.1721	0.1665	0.1871	0.1673
No. of Groups	253	253	253	253	253	253	253	253

Note: This table identifies the results between innovation (Market and Product) and financial vulnerability with the moderating role of intellectual capital of the non-financial firms listed in the Pakistan Stock Exchange over the time 2010–2020. Panel A to D represent the results regarding market innovation, while panel E to H represent the results regarding product innovation. Financial vulnerability is the dependent variable, which was calculated based on the equity ratios. Innovation (Innov) is the independent variable. The intellectual capital was measured using three different proxies, like human capital, structural capital, and customer capital employed. HCE is the human capital employed, SCE is the structural capital employed, and CEE is the customer capital employed. VAIC is the value-added intellectual capital and was measured based on the sum of human capital, structural capital, and customer capital. Innov × HCE is the interaction term of human capital employed with innovation. Innov × SCE is the interaction term of structural capital employed with innovation. Innov × CEE is the customer capital employed with innovation. Innov × VAIC is the interaction term of valued-added intellectual capital with innovation. Age is the firm age, which was calculated based on the number of years the firm had been established. FS is the firm size, and it was calculated based on the total assets log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total sales). Lev is the financial ratio of a firm and was calculated based on the debt ratio (total debt divided by total assets). The figure in parentheses shows the standard error, and ***, **, and * represent the 1%, 5%, and 10% significance levels, respectively.

4.3. Robustness of Results

To test the robustness of the results in Table 3, we used three alternative measures of financial vulnerability, the operating margin ratio (FV_{OM}), the administrative cost ratio (FV_{AC}), and the financial distress (FD), as the dependent variable for the regression model (1), re-performed the empirical analyses, and reported the results related to each alternative measure of financial vulnerability in Tables 4–6, respectively. As shown in Tables 4–6, the coefficients on the interaction term between innovation and intellectual capital (Innov × IC) remain significantly positive ($p < 0.05$). As a higher value for the alternative measures of financial vulnerability indicates lower financial vulnerability for a firm, the empirical evidence from Tables 4–6 reinforces the findings from Table 3 that intellectual capital strengthens the association between innovation and the financial vulnerability of a firm. Alternatively, as Altman (1968) indicates that firms with an Altman Z score less than 1.8 have extremely high probabilities of bankruptcy, we also created an indicator variable that equals 1 if a firm has an Altman z score of less than 1.8, with 0 otherwise, to capture the

high financial distress a firm may face. Thereafter, we replaced the continuous value of the Altman Z score with the indicator variable of high financial distress as the dependent variable and used the logistic regression to conduct an additional analysis for Table 6. The results (un-tabulated) reveal the significantly negative coefficients based on the interaction term between innovation and intellectual capital (Innov × IC). As the lower probability of bankruptcy indicates lower financial vulnerability, the results (untabulated) further support the findings from Table 3.

Table 4. Estimation results between innovation and financial vulnerability (operating margin ratio). Role of intellectual capital.

Use the Operating Margin Ratio (FV_{OM}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$Innov_{(t-1)}$	0.0323 **	0.0572 ***	0.0384 ***	0.0324 ***	0.0103 ***	0.0362 ***	0.0627 ***	0.0306 ***
	(0.0110)	(0.0155)	(0.0113)	(0.0097)	(0.0036)	(0.0119)	(0.0105)	(0.0095)
$HCE_{(t-1)}$	0.0580 ***				0.0350 ***			
	(0.0139)				(0.0117)			
$SCE_{(t-1)}$		0.0383 ***				0.0320 ***		
		(0.0138)				(0.0132)		
$CEE_{(t-1)}$			0.0409 ***				0.0119 **	
			(0.0148)				(0.0060)	
$VAIC_{(t-1)}$				0.0252 ***				0.0357 ***
				(0.0103)				(0.0119)
$Innov_{(t-1)} \times HCE_{(t-1)}$	0.0268 ***				0.0292 *			
	(0.0059)				(0.0162)			
$Innov_{(t-1)} \times SCE_{(t-1)}$		0.0395 ***				0.0503 ***		
		(0.0149)				(0.0166)		
$Innov_{(t-1)} \times CEE_{(t-1)}$			0.0418 **				0.0784 ***	
			(0.0115)				(0.0137)	
$Innov_{(t-1)} \times VAIC_{(t-1)}$				0.0690 ***				0.0568 ***
				(0.0121)				(0.0133)
$Age_{(t-1)}$	−0.096	−0.0948 ***	−0.0016 **	−0.0012 ***	−0.0133 ***	−0.0086 ***	−0.0141 ***	−0.0065 **
	(0.065)	(0.0381)	(0.0007)	(0.0005)	(0.0054)	(0.0029)	(0.0054)	(0.0031)
$FS_{(t-1)}$	0.0091	0.0028	0.0059	0.0035	0.0203 **	0.0193 **	0.0202 **	0.0216 ***
	(0.0065)	(0.0047)	(0.0064)	(0.0052)	(0.0094)	(0.0091)	(0.0091)	(0.0089)
$EP_{(t-1)}$	−0.2577 ***	−0.3454 ***	−0.0137	−0.2623 ***	−0.2097 ***	−0.2077 ***	−0.2146 ***	−0.1966 ***
	(0.0399)	(0.0384)	(0.0421)	(0.0339)	(0.0432)	(0.0432)	(0.0427)	(0.0423)
$Lev_{(t-1)}$	0.0452	0.0096	0.0872 **	0.0361	0.0669	0.1028 ***	0.1038 **	0.1084 ***
	(0.0426	(0.0392)	(0.0419)	(0.0368)	(0.0478)	(0.0443)	(0.0442)	(0.0438)
Cons	0.8928 ***	0.9982 ***	0.9006	0.9567 ***	1.2659 ***	1.0603 ***	1.2506 ***	0.9305 ***
	(0.0676)	(0.0486)	(0.0673)	(0.0530)	(0.2334)	(0.1385)	(0.2266)	(0.1404)
R^2	0.1780	0.1377	0.1434	0.1996	0.1349	0.1522	0.1343	0.1134
No. of Groups	253	253	253	253	253	253	253	253
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table shows the results between financial vulnerability and innovation (Market and Product) with the moderating role of intellectual capital in non-financial listed firms in Pakistan. The financial vulnerability is the dependent variable in the above table, and it was calculated based on the low or negative operating margin ratio. Innovation (Innov) is the independent variable, while intellectual capital (IC) is the moderator. Panel A to D represent the results regarding market innovation, while panel E to H represent the results regarding product innovation. The intellectual capital was measured using three different proxies, like human capital, structural capital, and customer capital employed. HCE is the human capital employed, SCE is the structural capital employed, and CEE is the customer capital employed. VAIC is the valued-added intellectual capital and is the sum of human capital, structural capital, and customer capital. Innov × HCE is the interaction term of human capital employed with innovation. Innov × SCE is the interaction term of structural capital employed with innovation. Innov × CEE is the customer capital employed with innovation. Innov × VAIC is the interaction term of valued-added intellectual capital with innovation. Age is the firm age, which was calculated based on the number of years since the firm's incorporation. FS is the firm size, and it was calculated based on the total assets log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total sales). Lev is the financial ratio of the firm and was calculated based on the debt ratio (total debt divided by total assets). The figure in parentheses shows the standard error, and ***, **, and * represent the 1%, 5%, and 10% significance levels, respectively.

Table 5. Estimation results between innovation and financial vulnerability (administrative cost ratio). Role of intellectual capital.

Use the Administrative Cost Ratio (FV_{AC}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$Innov_{(t-1)}$	0.0337 ***	0.0647 ***	0.0144 ***	0.0216 ***	0.0197 ***	0.0173 ***	0.0454 ***	0.0379 ***
	(0.0107)	(0.0096)	(0.0072)	(0.0084)	(0.0082)	(0.0068)	(0.0091)	(0.0090)
$HCE_{(t-1)}$	0.0821 ***				0.0171 **			
	(0.0136)				(0.0085)			
$SCE_{(t-1)}$		0.0201 **				0.0258 **		
		(0.0093)				(0.0071)		
$CEE_{(t-1)}$			0.0297 ***				0.0275 ***	
			(0.0115)				(0.0075)	
$VAIC_{(t-1)}$				0.0231 ***				0.0204 **
				(0.0109)				(0.0087)
$Innov_{(t-1)} \times HCE_{(t-1)}$	0.0181 **				0.0237 **			
	(0.0091)				(0.0120)			
$Innov_{(t-1)} \times SCE_{(t-1)}$		0.0212 ***				0.0673 ***		
		(0.0061)				(0.0103)		
$Innov_{(t-1)} \times CEE_{(t-1)}$			0.0454 ***				0.0554 ***	
			(0.0092)				(0.0110)	
$Innov_{(t-1)} \times VAIC_{(t-1)}$				0.0307 ***				0.0590 ***
				(0.0129)				(0.0179)
$Age_{(t-1)}$	0.0103	0.0498 ***	0.0483 ***	0.0010 **	0.0012 ***	0.0013 ***	0.0996 ***	0.0493 ***
	(0.0022)	(0.0101)	(0.0103)	(0.0005)	(0.0003)	(0.0003)	(0.0214)	(0.0103)
$FS_{(t-1)}$	−0.0184 ***	−0.0141 **	−0.0158 ***	−0.0127 ***	−0.0059 *	−0.0055 *	−0.0074 ***	−0.0169 ***
	(0.0066)	(0.0064)	(0.0065)	(0.0045)	(0.0032)	(0.0032)	(0.0026)	(0.0066)
$EP_{(t-1)}$	0.1367 ***	0.1348 **	0.1338 ***	0.1521 ***	0.1185 ***	0.1032 ***	0.1606 ***	0.0304
	(0.0310)	(0.0303)	(0.0307)	(0.0292)	(0.0221)	(0.0223)	(0.0226)	(0.0311)
$Lev_{(t-1)}$	0.0415	−0.1138 ***	−0.0127	−0.0110	−0.0621 ***	−0.0613 ***	−0.0336	−0.1089 ***
	(0.0321)	(0.0331)	(0.0333	(0.0296)	(0.0230)	(0.0230)	(0.0226)	(0.0337)
Cons	−0.1695 *	−1.7275 ***	−1.7072 ***	0.1551 ***	0.0843 ***	0.0801 ***	0.0992 ****	−1.7375 ***
	(0.0971)	(0.4161)	(0.4240)	(0.0487)	(0.0334)	(0.0335)	(0.0294)	(0.4335)
R^2	0.1065	0.1445	0.1260	0.1660	0.2099	0.2067	0.1374	0.1181
No. of Groups	253	253	253	253	253	253	253	253
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The above-mentioned table represents the results of the relationship between financial vulnerability and innovation (market and product) with intellectual capital as the moderator. The financial vulnerability is the dependent variable, which was calculated based on the admin cost ratio, while innovation (Innov) is the independent variable. Human capital employed (HCE), structural capital employed (SCE), and customer capital employed (CEE) are the intellectual capital's measurements. Value-added intellectual capital (VAIC) is the sum of all of these measurements. Panel A to D represent the results regarding market innovation, while panel E to H represent the results regarding product innovation. The significance of the Hausam test suggested applying the fixed effect model for the estimation. Innov × HCE is the interaction term of human capital employed with innovation. Innov × SCE is the interaction term of structural capital employed with innovation. Innov × CEE is the customer capital employed with innovation. Innov × VAIC is the interaction term of valued-added intellectual capital with innovation. Age is the firm age, which was calculated based on the number of years since the firm was incorporated. FS is the firm size, and it was calculated based on the total assets log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total sales). Lev is the financial ratio of the firm and was calculated based on the debt ratio (total debt divided by total assets). The figure in parentheses shows the standard error, and ***, **, and * represent the 1%, 5%, and 10% significance levels, respectively.

Table 6. Estimation results between innovation and financial vulnerability (financial distress). Role of intellectual capital.

Use the Financial Distress (FD) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$Innov_{(t-1)}$	0.0635 ***	0.0756 ***	0.0917 ***	0.1106 *	0.0807 ***	0.1421 **	0.0884 *	0.2066 ***
	(0.0056)	(0.0172)	(0.0284)	(0.0590)	(0.0151)	(0.0642)	(0.0487)	(0.0729)
$HCE_{(t-1)}$	0.1468 **				0.1399 *			
	(0.0716)				(0.0808)			
$SCE_{(t-1)}$		0.2209 ***				0.0148 **		
		(0.0907)				(0.0071)		
$CEE_{(t-1)}$			0.2836 ***				0.0539 ***	
			(0.0906)				(0.0094)	
$VAIC_{(t-1)}$				0.0912 ***				0.1669 **
				(0.0222)				(0.0820)

Table 6. *Cont.*

Use the Financial Distress (FD) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$\mathbf{Innov_{(t-1)} \times HCE_{(t-1)}}$	0.1642 **				0.1632 **			
	(0.0811)				(0.0828)			
$\mathbf{Innov_{(t-1)} \times SCE_{(t-1)}}$		0.1218 ***				0.1834 **		
		(0.0452)				(0.0897)		
$\mathbf{Innov_{(t-1)} \times CEE_{(t-1)}}$			0.1796 **				0.1484 ***	
			(0.0822)				(0.0621)	
$\mathbf{Innov_{(t-1)} \times VAIC_{(t-1)}}$				0.1143 ***				0.2378 ***
				(0.0395)				(0.0613)
$\mathbf{Age_{(t-1)}}$	−0.0024	0.0684 ***	0.0731 *	0.1565 *	−0.0048	−0.0035	0.0057	−0.0026
	(0.0060)	(0.0057)	(0.0405)	(0.0889)	(0.0061)	(0.0061)	(0.0051)	(0.0061)
$\mathbf{FS_{(t-1)}}$	0.0348	0.0496	0.0392	0.0705	0.0390	0.0342	0.021	0.0435
	(0.0405)	(0.0394)	(0.0456)	(0.0492)	(0.0487)	(0.0429)	(0.0334)	(0.0428)
$\mathbf{EP_{(t-1)}}$	−0.0419	−0.0847	0.0420	−0.0037	0.0069	−0.0524	0.0950	−0.0810 ***
	(0.2131)	(0.2164)	(0.2292)	(0.2303)	(0.2560)	(0.2257)	(0.1849)	(0.0224)
$\mathbf{Lev_{(t-1)}}$	0.2114 **	0.4836 **	0.4959 **	0.5614 **	0.6459 **	0.4069	0.7649 ***	0.4467 *
	(0.1095)	(0.2243)	(0.2363)	(0.2397)	(0.3021)	(0.2483)	(0.2063)	(0.2458)
Cons	1.5270 ***	0.9989 ***	−1.7395 ***	−4.7248 ***	1.2331 **	1.5253	0.8853 ***	1.4441 ***
	(0.4669)	(0.4155)	(0.6874)	(1.2777)	(0.5327)	(0.4840)	(0.3718)	(0.4749)
$\mathbf{R^2}$	0.1960	0.2060	0.1412	0.2332	0.1069	0.1587	0.1294	0.1657
No. of Groups	253	253	253	253	253	253	253	253
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The above-mentioned table represents the results of the relationship between financial vulnerability and innovation (market and product) with intellectual capital as the moderator. The financial vulnerability is the dependent variable, which was calculated based on the Altman Z Score, while innovation (Innov) is the independent variable. Human capital employed (HCE), structural capital employed (SCE), and customer capital employed (CEE) are the intellectual capital's measurements. VAIC is the value-added intellectual capital (IC), and it is the sum of all these measurements (HCE, SCE, and CEE). Panel A to D represent the results regarding market innovation, while panel E to H represent the results regarding product innovation. The significance of the Hausam test suggested applying the fixed effect model for the estimation. Innov × HCE is the interaction term of human capital employed with innovation. Innov × SCE is the interaction term of structural capital employed with innovation. Innov × CEE is the customer capital employed with innovation. INNOV × VAIC is the interaction term of valued-added intellectual capital with innovation. Age is the firm age, which was calculated based on the number of years since the firm was incorporated. FS is the firm size, and it was calculated based on the total assets log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total sales). Lev is the financial ratio of a firm and was calculated based on the debt ratio (total debt divided by total assets). The figure in parentheses shows the standard error, and ***, **, and * represent the 1%, 5%, and 10% significance levels, respectively.

4.4. Test for Endogeneity

It is plausible that firms with lower financial vulnerability are more likely to have higher intellectual capital and innovation. Thus, our empirical result could be biased due to the endogeneity issues. To deal with the potential endogeneity issues, we adopted two additional approaches: the two-stage least squares (2SLS) method and the entropy balancing method (Hainmueller 2012; McMullin and Schonberger 2020). Tables 7 and 8 report the results for each test of endogeneity, respectively.

Table 7. Tests for endogeneity: two-stage least square.

Use the Equity Ratio (FV_{ER}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$\mathbf{Innov_{(t-1)}}$	0.0259 **	0.0514 ***	0.0281 ***	0.0285 **	0.0285 ***	0.0302 ***	0.0325 *	0.0329 **
	(0.0135)	(0.0103)	(0.0104)	(0.0139)	(0.0074)	(0.0118)	(0.0188)	(0.0164)
$\mathbf{HCE_{(t-1)}}$	0.0435 ***				0.0488 ***			
	(0.0135)				(0.0134)			
$\mathbf{SCE_{(t-1)}}$		0.0358 ***				0.0451 ***		
		(0.0143)				(0.0131)		
$\mathbf{CEE_{(t-1)}}$			0.0301 **				0.0391 ***	
			(0.0134)				(0.0117)	
$\mathbf{VAIC_{(t-1)}}$				0.0319 **				0.0470 ***
				(0.0138)				(0.0135)
$\mathbf{Innov_{(t-1)} \times HCE_{(t-1)}}$	0.0209 **				0.0559 ***			
	(0.0093)				(0.0142)			

Table 7. *Cont.*

Use the Equity Ratio (FV_{ER}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$\mathbf{Innov_{(t-1)} \times SCE_{(t-1)}}$		0.0411 ***				0.0447 ***		
		(0.0083)				(0.0108)		
$\mathbf{Innov_{(t-1)} \times CEE_{(t-1)}}$			0.0351 ***				0.0814 ***	
			(0.0084)				(0.0127)	
$\mathbf{Innov_{(t-1)} \times VAIC_{(t-1)}}$				0.0314 **				0.0706 ***
				(0.0139)				(0.0183)
$\mathbf{Age_{(t-1)}}$	0.00095 ***	0.0011 ***	0.0010 ***	0.00089 ***	0.00080 ***	0.00087 ***	0.00078 ***	0.00098 **
	(0.00036)	(0.00029)	(0.00034)	(0.00037)	(0.00032)	(0.00033)	(0.00031)	(0.00045)
$\mathbf{FS_{(t-1)}}$	−0.0071 **	−0.0070 ***	−0.0041	−0.0069 **	−0.0062 *	−0.0064 **	−0.0043	−0.0069 *
	(0.0031)	(0.0027)	(0.0034)	(0.0031)	(0.0033)	(0.0033)	(0.0033)	(0.0041)
$\mathbf{EP_{(t-1)}}$	0.2249 ***	0.1371 ***	0.2262 ***	0.2247 ***	0.2989 ***	0.2878 ***	0.2954 ***	0.2442 ***
	(0.04303)	(0.0315)	(0.0445)	(0.0449)	(0.0455)	(0.0464)	(0.0452)	(0.0528)
$\mathbf{Lev_{(t-1)}}$	−0.0067	−0.0233	−0.0073	−0.0026	0.0032	0.0079	−0.0022	−0.0148
	(0.0318)	(0.0196)	(0.0312)	(0.0307	(0.0287)	(0.0269)	(0.0277)	(0.0396)
Cons	0.1089 **	.1029 ***	0.0279	0.0816 *	0.0792 *	0.0450	0.0162	−0.0376
	(0.0492)	(0.0369)	(0.0419)	(0.0457)	(0.0443)	(0.0496)	(0.0402)	(0.1017)
$\mathbf{R^2}$	0.1049	0.1330	0.1121	0.1065	0.1069	0.1582	0.2036	0.1781
No of Groups	253	253	253	253	253	253	253	253
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table shows the results of two-stage least square. Financial vulnerability is the dependent variable, which was calculated based on equity ratios. Innovation (Innov) is the independent variable, which is categorized as market innovation and product innovation. The intellectual capital was measured using three different proxies, like human capital, structural capital, and customer capital employed. HCE is the human capital employed, SCE is the structural capital employed, and CEE is the customer capital employed. VAIC is the value-added intellectual capital and was measured based on the sum of human capital, structural capital, and customer capital. Innov × HCE is the interaction term of human capital employed with innovation. Innov × SCE is the interaction term of structural capital employed with innovation. Innov × CEE is the customer capital employed with innovation. Innov × VAIC is the interaction term of valued-added intellectual capital with innovation. Age is the firm age, which was calculated based on the number of years the firm was established. FS is the firm size, and it was calculated based on the total assets log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total sales). Lev is the financial ratio of a firm and was calculated based on the debt ratio (total debt divided by total assets). The values in parentheses are standard errors, while "***", "**", and "*" show the significance levels at 1%, 5%, and 10%, respectively.

Table 8. Tests for endogeneity: entropy balancing method.

Use the Equity Ratio (FV_{ER}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
$\mathbf{Innov_{(t-1)}}$	0.0426 ***	0.0353 ***	0.0322 ***	0.0353 ***	0.0256 ***	0.0271 ***	0.0619 ***	0.0488 **
	(0.0089)	(0.0119)	(0.0095)	(0.0123)	(0.0052)	(0.0109)	(0.0119)	(0.0084)
$\mathbf{HCE_{(t-1)}}$	0.0406 ***				0.0464 **			
	(0.0159)				(0.0124)			
$\mathbf{SCE_{(t-1)}}$		0.0361 ***				0.0281 **		
		(0.0152)				(0.0128)		
$\mathbf{CEE_{(t-1)}}$			0.0574 *				0.0330 ***	
			(0.0159)				(0.0106)	
$\mathbf{VAIC_{(t-1)}}$				0.0146 **				0.0353 ***
				(0.0072)				(0.0136)
$\mathbf{Innov_{(t-1)} \times HCE_{(t-1)}}$	0.0268 ***				0.0556 ***			
	(0.0093)				(0.0176)			
$\mathbf{Innov_{(t-1)} \times SCE_{(t-1)}}$		0.0332 **				0.0448 **		
		(0.0102)				(0.0105)		
$\mathbf{Innov_{(t-1)} \times CEE_{(t-1)}}$			0.0649 ***				0.0452 **	
			(0.0147)				(0.0129)	
$\mathbf{Innov_{(t-1)} \times VAIC_{(t-1)}}$				0.0330 ***				0.0489 ***
				(0.0130)				(0.0160)
$\mathbf{Age_{(t-1)}}$	0.0883 **	0.0979 **	0.0069 *	0.0092 **	0.0880 **	0.0069 *	0.0958 **	0.0010 **
	(0.0383)	(0.0454)	(0.0038)	(0.0045)	(0.0369)	(0.0039)	(0.0456)	(0.0005)
$\mathbf{FS_{(t-1)}}$	0.0074 **	0.0109 ***	−0.0089 **	−0.0113 ***	−0.0069 **	−0.0081 **	−0.0105 ***	−0.0130 ***
	(0.0030)	(0.0041)	(0.0040)	(0.0041)	(0.0032)	(0.0041)	(0.0039)	(0.0045)
$\mathbf{EP_{(t-1)}}$	0.2842 ***	0.3057 ***	0.2882 ***	0.3352 ***	0.2843 ***	0.2655 ***	0.3357 ***	0.1694 **
	(0.0609)	(0.0747)	(0.0622)	(0.0745)	(0.0574)	(0.0623)	(0.0754)	(0.0795)
$\mathbf{Lev_{(t-1)}}$	0.0093	0.0057	0.0056	0.0205	0.0151	−0.0309	0.0204	−0.0219
	(0.0303)	(0.0356)	(0.0330)	(0.0373)	(0.0250)	(0.0344)	(0.0380)	(0.0338)
Cons	0.0299 **	0.1085 **	0.1072 **	0.0770 ***	0.0506 ***	0.1009 ***	0.0497	0.1108 **
	(0.0145)	(0.0545)	(0.0486)	(0.0169)	(0.0168)	(0.0418)	(0.0531)	(0.0552)

Table 8. *Cont.*

Use the Equity Ratio (FV_{ER}) to Proxy for Financial Vulnerability as the Dependent Variable in All the Columns								
Variables	**Market Innovation**				**Product Innovation**			
	Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**
R^2	0.1584	0.1966	0.1582	0.1735	0.1559	0.1469	0.1941	0.1425
No of Groups	253	253	253	253	253	253	253	253
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table shows the entropy balancing method results. Financial vulnerability is the dependent variable, which was calculated based on equity ratios. Innovation (Innov) is the independent variable, which is categorized as market innovation and product innovation. The intellectual capital was measured using three different proxies, like human capital, structural capital and customer capital employed. HCE is the human capital employed, SCE is the structural capital employed, and CEE is the customer capital employed. VAIC is the value-added intellectual capital and was measured based on the sum of the human capital, structural capital, and customer capital. Innov × HCE is the interaction term of human capital employed with innovation. Innov × SCE is the interaction term of structural capital employed with innovation. Innov × CEE is the customer capital employed with innovation. Innov × VAIC is the interaction term of valued-added intellectual capital with innovation. Age is the firm age, which was calculated based on the number of years the firm was established. FS is the firm size, and it was calculated based on the total assets log. EP is the economic performance, and it was calculated based on the return on sale (EBIT divided by total sales). Lev is the financial ratio of a firm and was calculated based on the debt ratio (total debt divided by total assets). The values in parentheses are standard errors, while "***", "**", and "*" show the significance levels at 1%, 5%, and 10%, respectively.

To reduce the endogeneity concern (e.g., the potential reverse causation between the dependent and independent variables; the potential high correlation between the standard error of the regression model and the independent variable), in Table 7, we apply the instrumental variable method. Specifically, we follow the extant literature (e.g., Ma and Ji 2019; Wu et al. 2012) and use the industry mean value of intellectual capital in a year as an instrumental to run a two-stage least squares (2SLS) regression as follows: for the first-stage regression, we individually regress each measure of the intellectual capital of a firm (in continuous value) based on the industry mean value for each measure of intellectual capital in a year, as well as the same control variables used in the baseline regression, and predict the value for each measure of the intellectual capital of a firm. Then, we re-create the new indicator variable for each measure of intellectual capital based on the median predicted value of the measure and individually apply the new indicator variable for each measure of intellectual capital to the second-stage regression. The outcomes from the second-stage regressions in Table 7 further support our earlier findings in Table 3 as the coefficients based on the interaction terms between innovation and intellectual capital remain significantly positive ($p < 0.05$).

In Table 8, we apply the entropy balancing method (Hainmueller 2012; McMullin and Schonberger 2020) to remove the sample selection biases. Specifically, we reweight our observations to ensure that the distributional characteristics of the treatment and the control groups are similar to the post- weighting distributional characteristics and re-estimate the regression model (1) based on the new weight generated from the entropy balancing method. As can be seen from Table 8, the coefficients for the interaction terms between innovation and intellectual capital remain significantly positive ($p < 0.05$), similar to the results in Table 3.

5. Discussion on the Empirical Results

Our empirical evidence suggests that innovation has a positive effect on reducing the financial vulnerability of a firm. It is possible that innovative firms face less financial vulnerability due to the decline in financial risk and the increase in financial performance. Innovation is routinely generated using open technology and high-quality open tools and depends on a particular kind of expertise and information system (Slater et al. 2010). Moreover, firms focusing on market and product innovation have the competitive edge over other firms that help them to be sustained in the market financially. Innovation is inversely related to financial development in terms of financial vulnerability, as financial distress decreases through innovative techniques (Umar et al. 2020). The innovative

behavior develops the customer's interest towards the purchase of products; resulting in an increase in sales and revenues, which decreases the level of financial vulnerability (Cefis et al. 2020). Thus, financial vulnerability decreases due to good innovation and good relations with customers.

Additionally, our empirical evidence also suggests that intellectual capital contributes positively to reducing the financial vulnerability of a firm and that intellectual capital can strengthen the association between innovation and the financial vulnerability of a firm. We conclude that efficient intellectual capital is the effective knowledge capability for the effective utilization of available resources to enlighten the innovation, which eventually contributes to better financial performance and lower vulnerability in a competitive market (Darroch 2005). Intellectual capital brings innovation in terms of new elements in the product and new product development. The new elements help firms to maintain better performance and a good position in the market, which lessen their financial vulnerability. Moreover, an increased level of intellectual capital (human capital employed, structural capital, and customer capital employed) brings new ideas and technologies to achieve the desired goals (Kalkan et al. 2014; Örnek and Ayas 2015). As a result, firms with a higher level of intellectual capital and innovation normally have a stable position in the industry and better performance and thus have less financial vulnerability and low chances of bearing financial losses due to bankruptcy.

6. Conclusions

Using a hand-collected sample of the non-financial firms listed on the Pakistan Stock Exchange (PSX) over the period of 2011–2021, we investigate the role of intellectual capital in the association between innovation and financial vulnerability, and we find that intellectual capital strengthens the association between innovation and the financial vulnerability of a firm. The results are conclusive and robust across the alterative measures of the financial vulnerability, innovation, and intellectual capital, as well as the adoption of various tests for endogeneity. Our empirical evidence suggests that innovation, intellectual capital, and the joint effect between innovation and intellectual capital can positively contribute to the reduction in financial vulnerability faced by a firm. The study recommends that management should implement innovative product and marketing strategies, in addition to hiring knowledgeable and well-educated technical employees, to manage the financial vulnerability faced by a firm.

Our study has some limitations, which need to be addressed by future research in the area. For example, the study evaluates financial vulnerability using a few financial ratios, whereas there are a variety of additional ratios and non-financial indicators that can be used to proxy for financial vulnerability. Thus, we suggest that future research can use additional ratios to proxy for financial vulnerability and re-examine the topic. Additionally, due to data availability, we only conducted research using data from the Pakistan Stock Exchange (PSX), and our results may not be transferable to other countries. As a result, we may not be able to paint a complete picture regarding the joint effect of intellectual capital and innovation on the financial vulnerability of a firm in this study. Hence, we also suggest that future research expand the data to additional industries and countries to conduct a more comprehensive study on the topic. Moreover, as a strong corporate governance can help a firm build a better operating environment, as well as inducing optimal executives' behaviors, it is reasonable to assume that a strong corporate governance may positively influence the joint effect of intellectual capital and innovation on the financial vulnerability of a firm. However, this topic is out of the scope for this study, and we thus suggest that future research takes the effect of corporate governance into consideration for an empirical analysis.

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Appendix A

Table A1. Variable calculation.

Variables	Proxies	Measurement	Evidence
Dependent Variable	• Equity ratio (FV_{ER})	• Total equity to total revenue	(Tuckman and Chang 1991)
	• Operating margin ratio (FV_{OM})	• (Total revenue minus total expenses)/total revenue	Trussel (2002)
Financial Vulnerability (FV)	• Administrative cost ratio (FV_{AC})	• Administrative expenses to total expenses	Greenlee and Trussel (2000); Thomas and Trafford (2013)
	• Financial distress (FD)	• Altman Z score	(Altman 1968)
Independent Variable			
Innovation (Innov)	• Market innovation (MI) • Product innovation (PI)	Equals 1 if a firm introduces market or product innovation in the year, or 0 otherwise	Cefis et al. (2020), Ozer and Zhang (2015)
Moderating Variable			
Intellectual Capital (IC)	• Value-added intellectual capital (VAIC)	• Sum of HCE, SCE, and CEE	Pulic (2000); Farooq et al. (2022)
	• Human capital efficiency (HCE)	• Value added to human capital	
	• Structural capital efficiency (SCE)	• Structural capital to value added	
	• Capital employed efficiency (CEE)	• Value added to capital employed	
Control Variables			
Firm Age (Age)	• No. of years since the firm was established	• No. of years since the firm was established	Kou et al. (2020)
Firm Size (FS)	• Logarithm of total assets	• Logarithm of total assets	Lenihan et al. (2019)
Economic Performance (EP)	• Return on Sales	• EBITDA to total sales	Cefis et al. (2020)
Leverage (Lev)	• Leverage ratio	• Total debt to total assets	Kou et al. (2020)

Notes

1 As our sample covers over 60% (253/418) of the total non-financial firms listed on the Pakistan Stock Exchange (PSX), as well as over 20 industry sectors, we believe that our sample has good representation of the population, that is, the total non-financial firms listed on the PSX. More specifically, the hand-collection process allows us to further identify firms that fit our selection criterion, that is, firms need to continuously focus on innovation and maintain an efficient intellectual capital.

2 We use the lagged one-year value for all the independent variables to control for the potential causation issue between the dependent and independent variables.

3 Alternatively, Altman (1968) indicates that firms with an Altman Z score of less than 1.8 have high probabilities of bankruptcy. Thus, to proxy for the high financial distress a firm may face, we also create an indicator variable that equals 1 if a firm has an Altman z score of less than 1.8, with 0 otherwise. Then, we replace the continuous value of the Altman Z score with the indicator variable of high financial distress in the empirical analysis (result un-tabulated), which we will further explain in a later section.

4 From an econometric perspective, it is valid to use the continuous value of the intellectual capital measures in the regression analysis. However, when we take the interaction of the continuous value of intellectual capital with the indicator variable of innovation in a regression, the coefficient based on the interaction captures the effect of intellectual capital based on financial

vulnerability in the high-innovation group, whereas the coefficient based on the intellectual capital captures the effect of intellectual capital based on financial vulnerability in the low-innovation group, but our purpose is to capture the moderating effect of intellectual capital between innovation and financial vulnerability. To better interpret the economic effect of intellectual capital on the association between innovation and financial vulnerability, we turn all the intellectual capital measures into indicator variables. In this way, the coefficient based on the interaction captures the joint effect of high innovation and high intellectual capital on financial vulnerability, whereas the coefficient based on the intellectual capital captures the effect of high intellectual capital on financial vulnerability.

[5] All continuous variables used in the study are winsorized at 1% and 99% levels.

[6] A higher value for the proxies for the financial vulnerability indicates lower financial vulnerability of a firm.

[7] 2.7% is calculated as 0.0181/0.6623.

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