




ARTICLE



<https://doi.org/10.1057/s41599-023-02169-w>

OPEN

Concave-convex effect of financial resilience on corporate financial performance: quantile regression approach

XueHui Zhang¹, Kun-Shan Wu ²✉ & Mingwen He¹

This study not only aims to elucidate the curvilinear nexus between financial resilience (FR) and corporate financial performance (CFP) by drawing on the ‘too much of a good thing (TMGT)’ and ‘too little of a good thing (TLGT)’ effect but also attempts to examine whether the nonlinear relationship explains the conflicts found in previous findings. Data were analyzed from Taiwan publicly listed manufacturing firms amid the COVID-19 epidemic. Quantile regression approach results evidence that relationship between FR and CFP is of a concave-convex pattern. Moreover, the environmentally sensitive and non-sensitive firms are linked to CFP differently. The nexus between FR and CFP is concave for the environmentally sensitive firms, whereas the FR-CFP nexus is concave-convex for the environmentally non-sensitive firms. Overall, Taiwan’s manufacturing firms should carefully evaluate how capital is allocated to FR to avoid under- or over-investment in FR.

¹School of Economics and Management of Inner Mongolia University of Technology, Inner Mongolia 010051, China. ²Department of Business Administration, Tamkang University, Taipei 251301, Taiwan. ✉email: kunshan@mail.tku.edu.tw

Introduction

During a turbulent economy, a company's consistent profitability is not the result of even development, but of continuous adaptation to changing conditions, making financial resilience (FR) a crucial factor for a successful enterprise (Nkundabanyanga et al., 2019). Financially resilient enterprises have financial robustness, foresight, awareness, flexibility, and the ability to recover. These are all attributes that stimulate responses to financial shocks and determine the survival of companies in an unpredictable economy (Nkundabanyanga et al., 2019). From a financial standpoint, measuring an enterprise's resilience in terms of crises is an important indicator for investors (Rezaei Soufi et al., 2023).

FR plays a key role in the sustainability of enterprises and is a measure of their ability to prevent and/or recover from financial shocks in highly demanding financial environments. There is no agreed standard measure for FR as it is a dynamic concept—the ability to recover quickly from a shock to income or spending (McKnight and Rucci, 2020). When measuring FR, most indicators are assessed from the perspective of households or individuals (e.g., Kass-Hanna et al., 2022; Sakyi-Nyarko et al., 2022; Salignac et al., 2022; Yao et al., 2023). Hence, a more objective way to measure FR from an enterprise perspective would make up for subjective statements in the form of questionnaires. In addition, in accounting and auditing practice, the viability of a company is assessed on the basis of both liquidity and solvency in the balance sheet. Since financial flexibility (FF) is essentially based on stock information (FF is a firm's ability to access and restructure its financing at minimal costs; Gamba and Triantis, 2008), and cash conversion cycle (CCC) is the key measure of liquidity during a specific accounting period (CCC measures an enterprise's liquidity and how effective their working capital is managed; Deloof, 2003), this research assesses FR using measures of FF and the CCC from a stock and flow perspective.

The relationship between corporate financial performance (CFP) and FR is still a question that remains to be answered. Although some studies have examined the relationship between FF-CFP and CCC-CFP from the stock or flow perspective respectively, the findings are still inconclusive. From a stock information perspective, numerous studies indicate a positive FF-CFP nexus (Chun and Yanbo, 2016; Al-Slehat, 2019; Bilyay-Erdogan, 2020). Few studies, however, posit a negative FF-CFP nexus (Agha and Faff, 2014). Additionally, some articles focus on a concave (inverted U-shaped) FF-CFP nexus (Gu and Yuan, 2020; Yi, 2020) during non-pandemic periods, but more recent studies indicate a positive FF-CFP nexus (Teng et al., 2021), a concave FF-CFP nexus (Chang and Wu, 2022a; Zhang et al., 2022), and a concave-convex FF-CFP nexus (Chang and Wu, 2022b) amid COVID-19 periods.

From a flow information perspective, a series of research reports found a positive nexus between working capital management (WCM) (proxied by CCC) and CFP (Moussa, 2018; Baños-Caballero et al., 2020; Lyngstadaas, 2020; Amponsah-Kwatiah and Asiamah, 2021). Conversely, some articles argue that overinvestment in WCM may cause adverse effects and negatively influence enterprise profitability (Le, 2019; Ren et al., 2019; Wang et al., 2020; Akgün and Karataş, 2021). Recent articles, however, argue a nonlinear nexus between investment in WCM and enterprise profitability (Laghari and Chengang, 2019; Mahmood et al., 2019; Anton and Nucu, 2021). Research results thus far do not undeniably confirm whether FF (or CCC) increases or decreases CFP.

Unlike prior studies, where less attention has been paid by scholars to examine the effect of FR on CFP, hence, the primary research question is whether FR is linked to CFP. Furthermore, because the manufacturing industry is Taiwan's most advantageous industry due to its strong market influence and export

contribution, accounting for nearly 30% GDP (gross domestic product) in 2021, Taiwanese listed manufacturing firms are explored for this issue. The scope of the study covers 6051 listed manufacturing firm-quarters from the early phase of COVID-19 epidemic.

The purpose of this article is twofold. First, this research aims to identify whether FR is related to CFP and what this relationship looks like. It thus further expands the current research by clarifying the curvilinear FR-CFP relationship and filling the existing literature gap. Besides, companies with superior sustainability performance were more resilient to risk and experienced a smaller decline in financial performance than companies with poor sustainability performance during COVID-19 crisis (Lu et al., 2022). Furthermore, industry plays a vital role in sustainability research. Companies in environmentally sensitive industries face increasing pressure from stakeholders including shareholders, regulators, and communities to improve their sustainability performance (Brahmana and Kontesa, 2021). Consequently, the second aim is to further understand the potential distinctness in terms of the FR-CFP nexus for environmentally sensitive and non-sensitive industries.

To achieve these objectives, financial data from Taiwan publicly listed manufacturing firms were collected amid the COVID-19 epidemic. To analyze the data, in line with Chang and Wu (2021, 2022a, b) and Zhang et al. (2022), the quantile regression (QR) approach was utilized to explore both CFP's tail information (proxied by Tobin's Q) and the effect of FR on different Tobin's Q quantiles, which leads to superior reliability in the estimated results compared with the conventional ordinary least squares (OLS) approach. Additionally, steered by the existing literature on the U-shaped relationship (Haans et al. 2016; Lind and Mehlum, 2010), the article provides further examination on whether a curvilinear FR-CFP relationship exists.

The findings, based on the QR approach, reveal a curvilinear (either concave or convex) relationship between FR and CFP, which supports the theories of both the 'too much of a good thing (TMGT)' and 'too little of a good thing (TLGT)' effects. Similarly, a concave (inverted U-shaped) FF-CFP nexus exists among firms with lower (10th and 25th) and median (50th) Tobin's Q quantiles, and a U-shaped (convex) effect among firms with the 90th quantile. Additionally, environmentally sensitive firms have a concave FR-CFP relationship. In terms of environmentally non-sensitive firms, the findings reveal a curvilinear (either concave or convex) FR-CFP nexus. Moreover, the findings also reveal a concave (inverted U-shaped) FR-CFP nexus in firms with lower (10th and 25th) quantiles market-based performance, and a U-shaped (convex) FR-CFP nexus in firms with high (75th and 90th) quantiles market-based performance.

The results of this research enrich current literature and provide a variety of significant insights for company managers. Using a synthesized stock and flow perspective, the findings provide a more comprehensive understanding of the FR-CFP relationship in the different Tobin's Q quantiles of TSE listed manufacturing industry firms by identifying a nonlinear FR-CFP nexus. The findings also clarify Pierce and Aguinis's (2013) existing inconclusive results on the TMGT meta-theory by evidencing the nonlinear relationship between FR and CFP. By utilizing the QR approach, the research identifies the curvilinear (either inverted U-shaped or U-shaped) FR-CFP nexus. Steered by the existing literature on the U-shaped relationship (Haans et al. 2016; Lind and Mehlum, 2010), the article provides further evidence for whether a curvilinear FR-CFP relationship exists. The managerial implication for companies, as suggested by the empirical findings, is that enterprises should ascertain their optimum FR level, as neither excess nor insufficient FR is favorable.

The rest of this study is organized as follows. Section 2 presents a literature review on the relationship between FR and CFP. Section 3 provides the data and methodology employed in this research. Section 4 describes empirical findings. Section 5 offers a discussion of the results, while Section 6 concludes the study.

Literature review

Financial resilience. The concept of FR as a management strategy in business is extremely diverse. FR refers to “the ability to access and draw on internal capabilities and appropriate, acceptable and accessible external resources and support in times of financial adversity” (Muir et al., 2016), and “the capacity to recover quickly from financial adversity (the ability to bounce back from financial shocks)” (McKnight and Rucci, 2020). At a basic level, FR means that a company has enough capital and the right type of capital to operate sustainably over the long-term (Herbert Smith Freehills LLP, 2021). FR is a basis on which to identify whether an enterprise can survive a crisis or economic uncertainty.

FR plays a key role in sustainability of enterprise and is a measure of an enterprise’s ability to adapt in response to forces that will negatively affect their competitive advantage. As there is no agreed standard measure for FR, this research adopts a number of measures found in existing literatures. Taylor (2013) indicated that adaptability, flexibility, and financial robustness are indicators of FR. Nkundabanyanga et al. (2019) also used adaptability and financial robustness, according to Taylor (2013), to measure FR, but their analysis ceased using flexibility due to measurement variance. Salignac et al. (2019), following Muir et al. (2016), developed a framework comprising of the four components that contribute to FR: “economic resources; financial products and services (financial inclusion); financial knowledge and behavior (financial capability); and social capital” (Jayasinghe et al., 2020).

The aforementioned indicators to assess FR are measured from the perspective of households or individuals (Muir et al., 2016; Salignac et al., 2019), most of whom make subjective statements in the form of questionnaires. Currently, there is no objective way to measure FR from an enterprise perspective.

In accounting and auditing practice, the viability of a company is assessed on the basis of both liquidity and solvency in the balance sheet. Enterprises need cash liquidity to cover everyday business activity expenses. Since FF is essentially information based on inventory at the end of an accounting period, if the key information of liquidity during a specific accounting period (CCC) can be added, then the financial indicator after merging the stock and flow financial information during a specific operating period can better reflect the comprehensive financial capacity of an enterprise to cope with financial shocks, uncertain economies, or operational crises.

From the above perspective, the ability to cope with negative income or expense shocks, or to recover quickly from periods of financial adversity is known as FR (McKnight and Rucci, 2020), and assessing FR includes measures of FF and CCC.

Nonlinear relationship between FR and CFP. To the authors’ knowledge, literature concerning the relationship between FR and CFP is scarce. As FR is proxied by FF and the CCC, the present article examines the connection between FF and CFP and the CCC and CFP to deduce the FR-CFP nexus.

First, there are competing views in the existing academic literature on the effects of FF on CFP. For example, Chun and Yanbo (2016), based on the free cash flow theory (Jensen, 1986), suggest FF has a significantly positive impact on CFP. A similar positive FF-CFP relationship is also reported by Teng et al. (2021). Another research reports a negative FF-CFP nexus. For

example, Agha and Faff (2014) from perspective of agency cost, claim that high FF leads to over-investment. More recently, differing results on the FF-CFP nexus has elicited doubt regarding the proposed linear relationship and consequently, the adoption of nonlinear models. For example, Yi (2020) evidence an inverted U-shape FF-CFP nexus. Initially, FF has a positive influence on CFP as the benefits outweigh the costs; however, once the threshold is surpassed, the effects revert to negative. A similar concave relationship is also reported by Gu and Yuan (2020), Chang and Wu (2022a), and Zhang et al. (2022).

Second, extant literature addresses the nexus between WCM (measured by the CCC) and CFP but have competing views on the relationship. Some previous studies demonstrate a negative linear relationship between WCM and CFP. For example, in Prasad et al.’s (2019) meta-analysis, most of their studies found a significant negative correlation between WCM and CFP. Conversely, numerous studies reports that WCM positively affects CFP. For example, Lin and Wang (2021) examined the effects of WCM (represented by CCC) on CFP and found that WCM positively affects CFP. A similar positive CCC-CFP relationship was also evidenced by Farhan et al. (2021) and Kayani et al. (2021).

A third viewpoint, focusing on the curvilinear pattern of the nexus between WCM and enterprise profitability, states an inverted U-shaped (concave) WCM-CFP nexus. For instance, Chambers and Cifter (2022) discovered a concave nexus between WCM and CFP in hospitality and tourism industry. A similar concave WCM-CFP relationship was also reported by Laghari and Chengang (2019), and Mahmood et al. (2019).

Although the above discussion highlights the impact of FF and the CCC on CFP from a stock and flow perspective, respectively, no empirical studies synthesize stock and flow perspectives to investigate the relationship between FR (proxied by FF and the CCC) and CFP, and what this relationship looks like. Therefore, the primary purpose of this article is to examine the FR-CFP nexus (FR is proxied by FF and the CCC) of manufacturing firms during the COVID -19 shocks by synthesizing stock and flow perspectives.

Overview of Quantile regression approach. Recently, the novel quantile regression (QR) approach has been widely applied to panel data, covering a wide area of research. The QR approach was used to calculate a set of regression functions, each corresponding to a different quantile of the conditional volatility distribution. QR approach gives similar results of OLS regression, but QR is more robust to nonnormal errors and outliers (Koenker and Bassett, 1978), whereas OLS can be inefficient when errors are highly non-normal. Also, regression coefficients for specific quantiles can be easily compared with least squares estimates.

The QR method provides more flexible and comprehensive determinant features in the upper and lower tailed of the distribution, and is widely used in corporate governance research (Chang and Wu, 2022a, b; Zhang et al., 2022).

Methodology

Sample composition. In this paper, manufacturing firms listed on the Taiwan Stock Exchange (TSE) were studied. Taiwan’s manufacturing industry contributes to approximately 30% of its gross domestic product (GDP), making it essential for Taiwan’s economic development. From the sampled manufacturing companies, 6051 firm-quarters were selected from the early phase of the COVID-19 epidemic (between Q1 2020 and Q3 2021) as the objects of study.

Variables

Dependent variable. Due to the current extensive usage of Tobin’s Q in WCM (measured by CCC) and FF literature, in this research

Table 1 Summary of descriptive statistics.

Variables	Tobin's Q	FR	REVG	BNIG	OEG	ARD	RDG	SIZE	LEV
Mean	5.779	0.791	15.547	117.327	7.115	70.463	0.038	15.059	44.937
Standard deviation	8.971	0.316	55.28	494.606	20.581	43.071	0.057	1.557	17.937
Min	0.91	0.185	-75.03	-1290.71	-36.88	0.91	0	11.252	5.97
Max	68.352	1.881	338.94	2981.97	107.47	258.16	0.341	19.575	86.08
10th percentile	1.445	0.443	-29.31	-106.41	-9.7	23.42	0	13.297	19.89
25th percentile	2.088	0.573	-10.67	-32.135	-2.83	41.17	0.002	14.013	32.48
50th percentile	3.204	0.749	6.215	24.4	3.205	65.03	0.019	14.910	45.28
75th percentile	5.647	0.958	28.07	121.07	12.09	91.67	0.045	15.950	57.8
90th percentile	10.793	1.167	58.75	374.145	27.1	121.2	0.097	17.122	67.41
Skewness	4.923	0.96	3.213	3.326	2.155	1.336	2.963	0.487	-0.018
Kurtosis	31.015	4.474	18.119	20.191	10.61	6.365	13.525	3.392	2.505

the dependent variable for CFP is proxied by Tobin's Q (Chancharat and Kumpamool, 2022; Chang and Wu, 2022a; Yeon et al., 2021). Tobin's Q is calculated by "book value of total assets - book value of common equity + market value of common equity) / book value of total assets".

Explanatory variable. The explanatory variable is financial resilience. Based on the previously discussed literature, this research uses FF and CCC as proxy variables for FR. In existing research, either a single-indicator method (for example, cash holding) (Marchica and Mura, 2010), or the multi-indicator method (for example, a consolidation of cash holdings and financial leverage) is used to measure FF (Arslan-Ayaydin et al., 2014). Given there is no universally accepted method to measure FF, this research adopts the findings of other researchers (Arslan-Ayaydin et al. 2014), where FF is calculated as

$$\begin{aligned} \text{FF} &= \text{Cash flexibility} + \text{Debt flexibility} \\ &= (\text{cash} + \text{cash equivalent}) / \text{total assets} \\ &\quad + (1 - \text{total liabilities} / \text{total assets}) \end{aligned} \quad (1)$$

The formula for measuring CCC is taken from Goel and Sharma (2015) and is calculated by adding the average number of days inventory (INV) plus the average number of days accounts receivable (AR), and then subtracting the average number of days accounts payable (AP). That is,

$$\text{CCC} = \text{INV} + \text{AR} - \text{AP} \quad (2)$$

where INV is equal to (Inventory / Cost of Sales) × 365; AR is equal to (Account receivables / Sales) × 365; and AP is equal to (Accounts Payables / Purchases) × 365.

A shorter CCC is favorable, but a negative CCC is possible. A negative CCC implies that the company effectively manages its working capital, can buy and sell inventory, and collects corresponding accounts receivable before corresponding payables are due.

According to the above-mentioned measurements of FF and CCC, FR as proxy is measured as $\text{FR} = \text{FF} + 1/\text{CCC}$. If CCC is negative, it indicates the liquidity of the enterprise is excellent, and the value of $1/\text{CCC}$ is set to 1.

Control variables. Several control variables were included in the model in line with the findings of other authors (Chang and Wu, 2022a; Teng et al., 2021), that could have the potential to influence CFP. Average collection days (ARD) = 365 days (per year) / accounts receivable turnover ratio; Net profit growth rate before taxes (BNIG) = (net profit before tax in the current period - net profit before tax in the previous period) / net profit before tax in the previous period; Financial leverage (LEV) equals to total liabilities divided by total assets; Growth rate of owner's equity

(OEG) equals to the percentage change in owner's equity over the prior period; Research and development intensity (RDG) = research and development expenditures / sales; Growth rate of revenue (REVG) is the percentage of revenue growth on a quarterly basis; Firm size (SIZE) is computed as the natural logarithm of the total assets.

Research model and methods. QR approach is more robust and can effectively capture outliers (Maiti, 2021), which is why researchers studying business management also use this model (Chang and Wu, 2022a, b). For example, Chang and Wu (2022a) employ the QR approach to study the relationship between FF and semiconductor industry performance. Chang and Wu (2022b) also utilize the QR approach to investigate the link between FF and hospitality industry performance. Similarly, Zhang et al. (2022) utilizes the QR approach analyze the connection between FF and hotel performance during COVID-19 periods. This study utilizes Koenker and Bassett's (1978) QR model, Eq. (3), to examine the curvilinear relationship between FR and CFP across different Tobin's Q quantiles.

$$Q_{\pi}(Tq_{it}|X_{it}) = \beta_{0\pi} + \beta_{1\pi}FR_{it} + \beta_{2\pi}FR2_{it} + \beta_{3\pi}CON_{it} + \mu_{\theta t} + \varepsilon_{\theta it} \quad (3)$$

where $Q_{\pi}(Tq_{it}|X_{it})$ is the π -th quantile regression function; Tq_{it} indicates the Tobin's Q of i company during quarter t ; FR_{it} indicates the FR for company i in t quarter; $FR2_{it}$ indicates the $FR_{it} * FF_{it}$; CON_{it} refers to the control variables; $\mu_{\theta t}$ signifies the time fixed effect; and $\varepsilon_{\theta it}$ denotes the remaining disturbance.

Moreover, steered by the existing literature on the U-shaped relationship (Haans et al. 2016; Lind and Mehlum, 2010), we provide further examination of a curvilinear FR-CFP association.

Results

Descriptive statistics. For the sample, key variable statistics are outlined in Table 1. At 0.791, the mean value of FR is low. Regarding the dependent variable, Tobin's Q, the mean is 5.779, median 3.204, and the minimum (maximum) value is 0.91 (68.352). The skewness and kurtosis indicate the manufacturing industry's Tobin's Q is skewed to right and heavily tailed. TSE listed manufacturing firms' Tobin's Q normality test reports the Jacque-Bera statistic (=220,000, $p < 0.01$) rejects the null hypothesis of a normal distribution. Figure 1 reveals the non-normal distribution, which is skewed to right and heavily tailed. These results support the use of a QR approach.

Furthermore, the low correlation between the independent variables indicates that there is no multicollinearity problem in our estimates (Table 2). ARD and SIZE negatively correlate with FR; BNIG, RDG, and OEG significantly and positively correlate with FR; and REVG does not significantly correlate with FR.

Besides, the values of variance inflation factor (VIF) are ranging from 1.07 to 1.88, which is less than threshold value 5 (Hair et al., 2017). As a result, multicollinearity is not considered to be an issue.

Curvilinear FR-CFP relationship. The OLS regression model estimates showed that the coefficients for FR and FR2 were not statistically significant ($p > 0.1$), inferring the FR-CFP nexus was insignificant. In terms of the QR approach, the coefficient of FR is significantly positive and the coefficient of FR2 is significantly negative ($p < 0.01$), which suggests the FR-CFP nexus is a curvilinear (inverted U-shaped) in the lower (10th and 25th) and median (50th) quantiles. However, the coefficients of FR and FR2 are significantly negative and positive respectively, suggesting a U-shaped FR-CFP relationship in the highest (90th) quantile (Table 3).

Additionally, the findings of both OLS and QR approaches indicate REVG, OEG, RDG, and LEV significantly affect CFP. The findings of both OLS and QR approaches reveal BNIG significantly affects CFP, except in the 10th quantile. For ARD and OLS, QR estimations reveal a significantly negative impact in the upper (75th and 90th) quantiles; nevertheless, in the lower quantiles, ARD significantly positively impacts CFP. The results confirm SIZE has a significant and negative impact on CFP (Table 3).

Furthermore, the present article also draws on the existing literature on the U-shaped association (Haans et al., 2016; Lind and Mehлум, 2010), where the following three conditions must be satisfied for an inverted U-shaped nexus between two variables: (i) the slope at lower bound (FR_L) is positive and significant ($4.1186, p < 0.01$); (ii) the slope at upper bound (FR_H)

is negative and significant ($-3.0518, p < 0.01$); and (iii) the inflection point (1.159) and the Fieller’s (1954) 95% confidence interval [1.09,1.24] are inside the range of data, which evidences the presence of an inverted U-shaped curvilinear FR-CFP association in the 10th quantile firms (Table 3). Likewise, an inverted U-shaped FR-CFP relationship is confirmed in the 25th and median quantile companies (Table 3).

QR results evidence a convex (U-shaped) connection between FR and CFP at 90th Tobin’s Q quantile. Further, through the U-test of the model, it is calculated that the slope at lower bound (FR_L) is negative and significant ($-8.7078, p < 0.01$), and the slope at upper bound (FR_H) is positive and significant (18.9679, $p < 0.01$). Moreover, the inflection point (0.719) and the Fieller’s 95% confidence interval [0.46,0.84] are inside the data range, confirming a U-shaped FR-CFP nexus exists in the 90th quantile (Table 3)

To sum up, the findings of QR method displays a concave FR-CFP nexus exists among firms with lower and median Tobin’s Q quantiles, and a convex FR-CFP nexus among firms with the 90th (highest) quantiles. Furthermore, the findings gathered from the QR approach are harmonious with some literatures present a concave FF-CFP nexus (Gu and Yuan, 2020; Yi, 2020) and a concave WCM-CFP nexus (Laghari and Chengang, 2019; Mahmood et al., 2019) during non-COVID-19 periods. The results are also agreed with some literatures reports a concave FF-CFP nexus (Chang and Wu, 2022a; Zhang et al., 2022) and a concave-convex FF-CFP nexus (Chang and Wu, 2022b) during COVID-19 periods.

Inter-quantile difference. Results confirm that the FR-CFP nexus is heterogeneous across CFP distribution. To verify whether these differences were significant, the inter-quantile regressions were employed to assess equality of slope across quantiles (Koenker and Bassett, 1978). Table 4 exhibits the result of the F-test and the corresponding p-values after applying the method of 200 bootstrap replications to check the uniformity of coefficients between the upper (75th and 90th) and lower (10th and 25th) and quantiles. For TSE listed manufacturing firms, the parameter estimates for the symmetrical quantiles (Quantile (90/10) and Quantile (75/25)) of FR and FR2 have a statistically significant difference.

Figure 2 illustrates how the impact of each covariable vary across quantiles and how they compare to OLS results for each independent variable. OLS and QR estimates give 95% confidence intervals, respectively. QR approach estimations are significantly different from the OLS estimations, particularly in the symmetrical quantiles (Quantile (90/10) and Quantile (75/25)). This reinforces the QR estimates differ significantly from the OLS estimates.

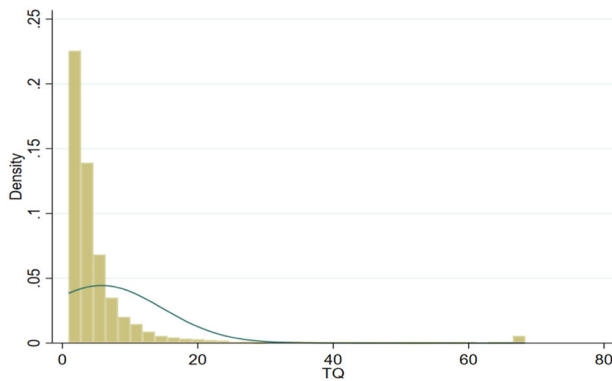


Fig. 1 Distribution of the dependent variable. This figure illustrates the histogram of Tobin’s Q.

Table 2 Correlation matrix of main variables.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) TQ	-								
(2) FR	0.040***	-							
(3) REVG	0.213***	-0.011	-						
(4) BNIG	0.036***	0.025**	0.330***	-					
(5) OEG	0.240***	0.105***	0.332***	0.215***	-				
(6) ARD	-0.073***	-0.135***	-0.172***	-0.097***	-0.029***	-			
(7) RDG	0.098***	0.241***	-0.015	-0.037***	0.069***	0.041***	-		
(8) SIZE	-0.348***	-0.214***	-0.065***	0.026*	0.015	-0.077***	-0.148***	-	
(9) LEV	0.053***	-0.651***	0.024*	-0.041***	-0.124***	0.079***	-0.207***	0.187***	-
VIF	-	1.88	1.29	1.15	1.19	1.07	1.09	1.10	1.82

* $p < 0.1$, ** $p < 0.05$; *** $p < 0.01$.

Table 3 Relationship between FR and CFP (proxied by Tobin's Q) across various quantile levels.

Variable	Tobin's Q					
	OLS	Quantile levels				
		10th	25th	50th	75th	90th
FR	-1.8208 (5.4602)	4.9007*** (0.3383)	5.1494*** (0.4568)	5.6123*** (0.6877)	-1.7006 (2.1804)	-11.7278*** (3.6283)
FR2	1.2888 (2.3439)	-2.1139*** (0.1735)	-1.9446*** (0.2439)	-1.8371*** (0.3935)	2.8656** (1.2121)	8.1594*** (1.6216)
REVG	0.0193*** (0.0071)	0.0031*** (0.0005)	0.0045*** (0.0006)	0.0091*** (0.0011)	0.0138*** (0.0027)	0.0401*** (0.0096)
BNIG	-0.0007** (0.0003)	0.0001 (0.0000)	-0.0001*** (0.0000)	-0.0003*** (0.0001)	-0.0004*** (0.0001)	-0.0009** (0.0004)
OEG	0.0990*** (0.0170)	0.0111*** (0.0012)	0.0222*** (0.0014)	0.0424*** (0.0031)	0.0911*** (0.0068)	0.1536*** (0.0205)
ARD	-0.0225*** (0.0070)	0.0021*** (0.0002)	0.0016*** (0.0004)	-0.0006 (0.0007)	-0.0094*** (0.0014)	-0.0218*** (0.0038)
RDG	10.2927* (5.5574)	0.9059* (0.4981)	2.2576*** (0.6094)	4.8308*** (0.8818)	14.5468*** (2.6433)	23.7337*** (5.6576)
SIZE	-2.0841*** (0.2838)	-0.2795*** (0.0071)	-0.3639*** (0.0082)	-0.6053*** (0.0132)	-0.9716*** (0.0433)	-1.6536*** (0.1049)
LEV	0.0839*** (0.0235)	0.0301*** (0.0019)	0.0383*** (0.0020)	0.0528*** (0.0021)	0.0774*** (0.0069)	0.1210*** (0.0161)
Constant	34.1860*** (6.4168)	2.0202*** (0.2699)	3.1275*** (0.2981)	6.6878*** (0.4051)	15.9232*** (1.3058)	32.7909*** (3.0943)
Observations	5,918	5,918	5,918	5,918	5,918	5,918
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.2298	0.0706	0.0838	0.0998	0.134	0.201
Slope at lower bound FR _L ($\beta_1 + 2*\beta_2*FR_L$)	-	4.1186***	4.4299***	4.9326***	-	-8.7078***
Slope at upper bound FR _H ($\beta_1 + 2*\beta_2*FR_H$)	-	-3.0518***	-2.1662***	-1.2989*	-	18.9679***
Sasabuchi test statistic	-	8.37***	4.28***	1.59*	-	2.87***
95% Fieller confidence interval	-	[1.09,1.24]	[1.21,1.49]	[1.32,2.02]	-	[0.46,0.84]
Threshold/within data range	-	1.159/Yes	1.324/Yes	1.527/Yes	-	0.719/Yes

Standard error in parentheses are the standard errors.
*p < 0.1, **p < 0.05, ***p < 0.01.

Table 4 Result of inter-quantile regression.

		CFP (proxied by Tobin's Q)	
		Quantile (90/10) Quantile (75/25)	
FR	F-statistics	13.67***	13.63***
	Significance	0.0002	0.0002
FR2	F-statistics	24.09***	22.04***
	P-value	0.0000	0.0000
REVG	F-statistics	5.60**	4.51**
	P-value	0.018	0.0338
BNIG	F-statistics	6.92***	5.67**
	P-value	0.0085	0.0173
OEG	F-statistics	13.94***	36.12***
	P-value	0.0002	0.0000
ARD	F-statistics	72.50***	66.36***
	P-value	0.0000	0.0000
RDG	F-statistics	15.52***	17.41***
	P-value	0.0001	0.0000
SIZE	F-statistics	170.94***	102.41***
	P-value	0.0000	0.0000
LEV	F-statistics	23.43***	29.30***
	P-value	0.0000	0.0000

Quantile (75/25) = 75th Quantile (y) - 25th Quantile (y); Quantile (90/10) = 90th Quantile (y) - 10th Quantile (y).
p < 0.05; *p < 0.01.

Robustness check. For sensitivity checks, as alternative measure of CFP, PRB (the price to book ratio) was utilized as recommended by Sharma and Bakshi (2019) and Keskin et al. (2020). The robustness test reinforces the primary results described in previous section, representing the concave (inverted U-shaped) FR-CFP relationship in TSE listed firms, especially in the lower and median quantiles. The consequences of the inverted U-shaped PBR relationship also align with the Tobin's Q results (Table 5). In addition, we replace the explanatory variable FR with FR_ind (financial resilience with industry adjustment). Table 6 shows the regression result, which is still line with the baseline regression.

Industry heterogeneity. In order to examine whether the FR-CFP relationship differs between environmentally sensitive (ES) and non-environmentally sensitive (non-ES) industries, the full sample firms were divided into firms operating in ES industries and those in non-ES industries. Firms in ES industries (such as oil, gas, paper, metal manufacturing, and chemical) are often considered as polluting sectors and perceived as having high environmental risk (Amor-Esteban et al. 2018; Yoon et al., 2018), and whose activities may have a direct impact on FR issues. The subsample of ES firms comprises 975 firm-quarters, and the subsample of non-ES firms comprises 4943 firm-quarters. Tables 7 and 8 show the estimation results for these subsamples.

In terms of the ES firms, the OLS results infer the FR-CFP nexus is insignificant (Table 7). QR approach results reveal that in all quantiles except the 90th, the coefficients of FR and FR2 are significantly positive and negative at the 1% level, respectively. This result confirms the existence of the inverted U-shaped FR-CFP

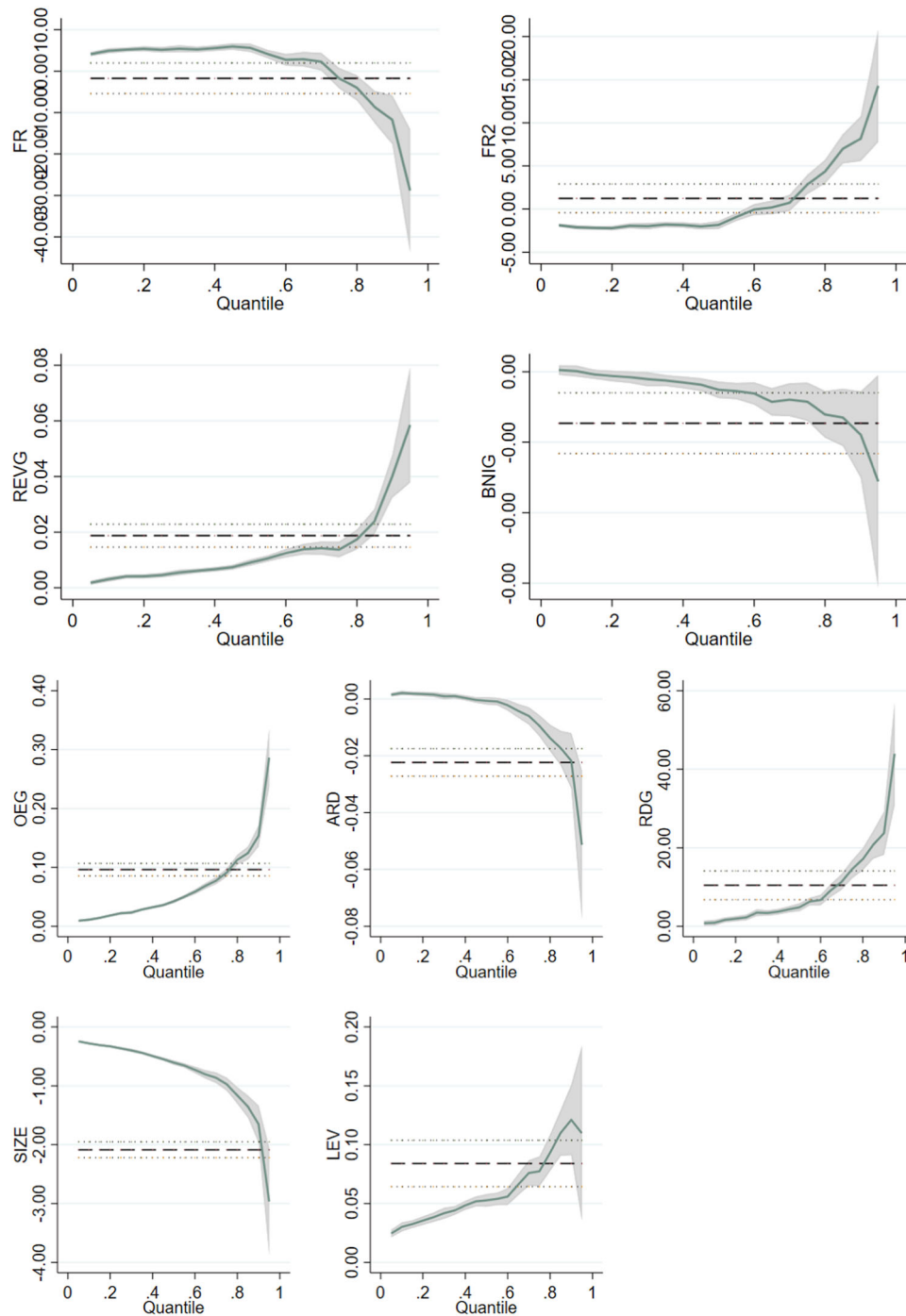


Fig. 2 Graphical representations of OLS and QR estimates. This figure illustrates how the impact of each covariable vary across quantiles and how they compare to OLS results for each independent variable.

nexus (Table 7). Furthermore, it is calculated that the slope at lower bound (FR_L) is positive and significant (3.4878, $p < 0.01$), but the slope at upper bound (FR_H) is negative and significant (-3.1388 , $p < 0.01$). Besides, the inflection point (1.078) and the 95% Fieller confidence interval [1.06,1.09] are inside the range of data. It verifies the presence of an inverted U-shaped curvilinear FR-CFP association in the 10th quantile companies (Table 7). Likewise, a concave nexus between FR and CFP is confirmed in the 25th, 50th, and 75th Tobin’s quantiles companies (Table 7).

To sum up, in terms of environmentally sensitive industries, QR method confirms the concave (inverted U-shaped) FR-CFP relationship exists in all Tobin’s Q quantiles except the 90th.

With regard to non-ES firms, the OLS results infer the FR-CFP nexus is insignificant (Table 8). QR approach results expose that in the lower and median quantiles, the coefficient of FR is positive and the coefficient of FR2 is negative, but both are significant ($p < 0.01$). This result reveals a concave (inverted U-shaped) FR-CFP. Nevertheless, QR approach results exhibit that in the upper quantiles, the coefficient of FR is negative and the coefficient of FR2 is positive, but both are significant ($p < 0.1$). This result reveals there is a confirmed U-shaped nexus between FR and CFP (Table 8).

Further results of the *U*-test show both slopes are significant. Additionally, the inflection point (1.192) of FR and the 95%

Table 5 Nonlinear FR-CFP nexus: using PBR.

Variable	Price-to-book ratio (PBR)					
	OLS	Quantile levels				
		10th	25th	50th	75th	90th
FR	-3.4436 (6.0460)	1.2121*** (0.1632)	1.5758*** (0.1580)	2.1386*** (0.2508)	1.6264*** (0.5585)	2.0394* (1.1712)
FR2	1.6725 (2.6182)	-0.6071*** (0.0709)	-0.7235*** (0.0688)	-0.8643*** (0.1161)	-0.4643 (0.2831)	-0.2688 (0.5284)
REVG	0.0005 (0.0018)	0.0009*** (0.0002)	0.0012*** (0.0002)	0.0021*** (0.0003)	0.0028*** (0.0006)	0.0040*** (0.0007)
BNIG	-0.0000 (0.0002)	-0.0000 (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0002*** (0.0000)	-0.0003*** (0.0001)
OEG	0.0091 (0.0089)	0.0077*** (0.0006)	0.0121*** (0.0006)	0.0181*** (0.0009)	0.0251*** (0.0017)	0.0317*** (0.0031)
ARD	-0.0002 (0.0026)	-0.0001 (0.0002)	-0.0007*** (0.0001)	-0.0013*** (0.0003)	-0.0029*** (0.0005)	-0.0048*** (0.0011)
RDG	6.2053*** (2.0131)	1.0698*** (0.2600)	2.2565*** (0.2766)	4.4810*** (0.4922)	7.8358*** (0.8218)	15.6122*** (1.8134)
SIZE	-0.3623 (0.2389)	-0.0582*** (0.0052)	-0.0635*** (0.0040)	-0.0799*** (0.0082)	-0.0736*** (0.0158)	-0.0222 (0.0308)
LEV	0.0210** (0.0092)	0.0087*** (0.0010)	0.0120*** (0.0009)	0.0184*** (0.0013)	0.0221*** (0.0025)	0.0397*** (0.0063)
Constant	7.8962 (6.7348)	0.6915*** (0.1405)	0.6627*** (0.1445)	0.6804*** (0.2052)	1.2308*** (0.4404)	0.1404 (0.9530)
Observations	5918	5918	5918	5918	5918	5918
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.0277	0.0505	0.0634	0.0773	0.0890	0.0968

Standard error in parentheses are the standard errors.
*p < 0.1, **p < 0.05; ***p < 0.01.

Table 6 Nonlinear FR-CFP nexus: using FR_ind.

Variable	Tobin's Q					
	OLS	Quantile levels				
		10th	25th	50th	75th	90th
FR_ind	0.2236 (1.9370)	1.5272*** (0.1304)	2.0760*** (0.1488)	2.7008*** (0.1836)	2.9208 (0.5757)	1.1798 (1.2173)
FR2_ind	1.3042 (2.3359)	-2.1188*** (0.1570)	-1.9462*** (0.2394)	-1.8293*** (0.3913)	2.7912** (1.2223)	8.1516*** (1.6137)
REVG	0.0193*** (0.0071)	0.0031*** (0.0005)	0.0046*** (0.0006)	0.0091*** (0.0009)	0.0139*** (0.0025)	0.0399*** (0.0096)
BNIG	-0.0007** (0.0003)	0.0000 (0.0000)	-0.0001*** (0.0000)	-0.0003*** (0.0000)	-0.0004*** (0.0001)	-0.0009*** (0.0003)
OEG	0.0987*** (0.0169)	0.0111*** (0.0012)	0.0221*** (0.0014)	0.0423*** (0.0031)	0.0913*** (0.0070)	0.1538*** (0.0208)
ARD	-0.0224*** (0.0069)	0.0021*** (0.0002)	0.0016*** (0.0004)	-0.0007 (0.0007)	-0.0093*** (0.0015)	-0.0218*** (0.0041)
RDG	10.3977* (5.5772)	0.9458* (0.4909)	2.2492*** (0.6393)	4.9111*** (0.8312)	14.9687*** (2.5970)	23.7491*** (5.4719)
SIZE	-2.0646*** (0.2794)	-0.2782*** (0.0060)	-0.3626*** (0.0083)	-0.6038*** (0.0156)	-0.9650*** (0.0338)	-1.6526*** (0.1099)
LEV	0.0834*** (0.0235)	0.0295*** (0.0018)	0.0382*** (0.0020)	0.0527*** (0.0025)	0.0779*** (0.0069)	0.1211*** (0.0162)
Constant	33.2607*** (4.5500)	4.5743*** (0.1329)	5.9688*** (0.1521)	9.9561*** (0.2710)	16.2145*** (0.6490)	28.6010*** (2.1033)
Observations	5918	5918	5918	5918	5918	5918
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.2285	0.0705	0.0838	0.0998	0.134	0.201

Standard error in parentheses are the standard errors.
*, **, *** represents statistical significance at 10%, 5%, and 1%, respectively.

Table 7 Nonlinear FR-CFP nexus: environmentally sensitive firms.

Variable	Tobin's Q					
	OLS	Quantile levels				
		10th	25th	50th	75th	90th
FR	-1.1268 (8.9676)	4.2106*** (0.3701)	4.6326*** (0.6118)	6.5921*** (0.8677)	7.5246*** (1.9330)	11.1034*** (3.9796)
FR2	1.0800 (4.7974)	-1.9536*** (0.1658)	-2.1601*** (0.2699)	-3.0007*** (0.4241)	-3.4976*** (0.9024)	-3.5141 (2.5889)
REVG	0.0152 (0.0094)	0.0021*** (0.0004)	0.0022*** (0.0008)	0.0047*** (0.0011)	0.0088*** (0.0027)	0.0143 (0.0087)
BNIG	0.0001 (0.0002)	0.0001* (0.0000)	0.0000 (0.0000)	0.0002** (0.0001)	0.0001 (0.0001)	-0.0005 (0.0004)
OEG	0.0510** (0.0228)	0.0099*** (0.0010)	0.0121*** (0.0018)	0.0137*** (0.0025)	0.0252*** (0.0049)	0.0492** (0.0233)
ARD	0.0129 (0.0083)	0.0042*** (0.0006)	0.0061*** (0.0007)	0.0068*** (0.0012)	0.0059*** (0.0021)	-0.0016 (0.0054)
RDG	-20.0001 (14.1225)	0.3187 (0.5840)	-2.1306 (1.3032)	-2.4265 (2.5990)	2.5188 (6.8211)	-17.8381** (7.1084)
SIZE	-0.7130*** (0.2431)	-0.2613*** (0.0059)	-0.2489*** (0.0134)	-0.2949*** (0.0148)	-0.4507*** (0.0402)	-0.5387*** (0.1203)
LEV	0.0072 (0.0238)	0.0238*** (0.0017)	0.0275*** (0.0032)	0.0336*** (0.0039)	0.0285*** (0.0097)	0.0634*** (0.0172)
Constant	12.8297* (7.5775)	2.2677*** (0.2562)	1.9563*** (0.4908)	1.8673*** (0.6059)	4.9576*** (1.4127)	4.4682 (2.9733)
Observations	975	975	975	975	975	975
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.2982	0.157	0.162	0.157	0.157	0.189
Slope at lower bound FR _L ($\beta_1 + 2*\beta_2*FR_L$)	-	3.4878***	3.8334***	5.4818***	6.2305***	-
Slope at upper bound FR _H ($\beta_1 + 2*\beta_2*FR_H$)	-	-3.1388***	-3.4937***	-4.6965***	-5.6334***	-
Sasabuchi test statistic	-	11.29***	7.43***	6.01	3.61***	-
95% Fieller confidence interval	-	[1.06,1.09]	[1.00,1.14]	[1.03,1.18]	[0.95,1.22]	-
Threshold/within data range	-	1.078/Yes	1.072/Yes	1.098/Yes	1.076/Yes	-

Standard error in parentheses are the standard errors.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Fieller confidence interval [1.14, 1.25] are inside the range of data, which confirms an inverted U-shaped FR-CFP relationship for firms in the lowest (10th) quantile. Similarly, the inverted U-shaped FR-CFP nexus is evident in the 25th quantile.

Regarding the median (50th) quantile, the QR results show a positive but insignificant slope for FR (3.6148, $p > 0.1$), whilst FR2 slope is positive and not significant (0.0654, $p > 0.1$). This indicates that for the 50th quantile, the true FR-CFP nexus is monotone increasing, thus the inverted U-shaped FR-CFP nexus cannot exist.

For the 75th quantile, the results of QR approach expose the slope at lower bound (FR_L) is negative and significant (-2.59, $p < 0.1$), however the slope at upper bound (FR_H) is positive and significant (10.8708, $p < 0.01$). In addition, the inflection point (0.511) and the 95% Fieller confidence interval [-0.14, 0.69] are inside the data ranges, verifying a convex (U-shaped) FR-CFP relationship in the 75th Tobin's Q quantile firms. Similarly, a U-shaped FR-CFP relationship is evident in the 90th Tobin's Q quantile firms.

In short, the QR results demonstrate the presence of an inverted U-shaped curvilinear FR-CFP relationship in the lower quantiles, and a curvilinear U-shaped FR-CFP nexus in the upper quantiles.

Discussion

This empirical study selected 6051 firm-quarters from TSE listed manufacturing firms during the early phase of the COVID-19

pandemic (between Q1 2020 and Q3 2021). Findings were elicited via the U-test.

Concave-convex FR-CFP relationship. First, the empirical results expose a concave (inverted U-shaped) FR-CFP nexus among firms with low and medium Tobin's Q quantiles. This means CFP initially increases as FR increases but on reaching the FR threshold, CFP decreases as FR increases, implying diminishing marginal returns. This association is summarized by Trumpp and Guenther (2017) TMGT effect, which explains that due to the law of diminishing marginal returns (LDMR), FR's impact on CFP ceases to be desirable beyond the threshold value.

The inflection points of 10th, 25th, and 50th quantiles are 1.159, 1.324, and 1.527 respectively, which is greater than the FR sample mean (0.791) (Table 3 and Fig. 3A-C). This indicates that most firms are located to the left of the inflection point, and evidence that the main FR-CFP nexus is curvilinear, positive, and significant. Accordingly, the majority of lower and median Tobin's Q quantile companies benefit from investing in FR and should maintain an optimal FR to obtain maximum CFP.

Second, in the highest (90th) quantile firms, QR results confirm a U-shaped (convex) FR-CFP nexus. Initially, CFP declines as FR increases; however, on surpassing the FR threshold value, CFP increases as FR increases. The foundation for such a relationship is the TLGT effect (Barnett and Salomon, 2012).

The threshold point of 90th quantiles is 0.719, which is lower than the current mean value of FR (0.791), indicating most firms are located to the right of the inflection point (Table 3 and

Table 8 The nonlinear FR-CFP nexus: environmentally non-sensitive firms.

Variable	Tobin's Q					
	OLS	Quantile levels				
		10th	25th	50th	75th	90th
FR	-2.3648 (5.9403)	4.5907*** (0.3276)	4.5099*** (0.4205)	4.0020*** (0.8471)	-4.0583* (2.2926)	-14.8363** (6.1976)
FR2	1.4763 (2.5149)	-1.9252*** (0.1472)	-1.5969*** (0.2375)	-1.0464** (0.4910)	3.9684*** (1.2731)	9.2400*** (2.7929)
REVG	0.0181** (0.0078)	0.0036*** (0.0006)	0.0049*** (0.0008)	0.0090*** (0.0015)	0.0140*** (0.0038)	0.0452*** (0.0137)
BNIG	-0.0009** (0.0004)	-0.0000 (0.0000)	-0.0001*** (0.0000)	-0.0003*** (0.0001)	-0.0007*** (0.0002)	-0.0014** (0.0007)
OEG	0.1084*** (0.0192)	0.0121*** (0.0012)	0.0246*** (0.0017)	0.0530*** (0.0040)	0.1083*** (0.0088)	0.1968*** (0.0299)
ARD	-0.0293*** (0.0080)	0.0007** (0.0003)	-0.0007*** (0.0002)	-0.0039*** (0.0006)	-0.0142*** (0.0019)	-0.0306*** (0.0051)
RDG	7.8463 (5.7637)	0.6483* (0.3587)	1.4152** (0.5612)	3.3596*** (0.9332)	12.7818*** (2.4898)	23.7764*** (7.4137)
SIZE	-2.3374*** (0.3278)	-0.2906*** (0.0086)	-0.4058*** (0.0099)	-0.7215*** (0.0191)	-1.1715*** (0.0456)	-2.1277*** (0.1809)
LEV	0.0939*** (0.0276)	0.0303*** (0.0020)	0.0381*** (0.0025)	0.0505*** (0.0023)	0.0812*** (0.0075)	0.1345*** (0.0286)
Constant	38.6584*** (7.1801)	2.4463*** (0.2947)	4.3139*** (0.3321)	9.6886*** (0.4638)	20.6223*** (1.3733)	42.6546*** (5.5017)
Observations	4943	4943	4943	4943	4943	4943
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo-R2	0.2355	0.0584	0.0724	0.0934	0.133	0.209
Slope at lower bound FR _L ($\beta_1 + 2*\beta_2*FR_L$)	-	3.8784***	3.9190***	3.6148	-2.59*	-11.4175**
Slope at upper bound FR _H ($\beta_1 + 2*\beta_2*FR_H$)	-	-2.6519***	-1.4976***	0.0654	10.8708***	19.9246***
Sasabuchi test statistic	-	10***	2.79***	NA	1.41*	2.20**
95% Fieller confidence interval	-	[1.14,1.25]	[1.25,1.69]	[1.39,14.18]	[-0.14,0.69]	[0.34,0.96]
Threshold/within data range	-	1.192/Yes	1.412/Yes	1.912/Yes	0.511/Yes	0.803/Yes

NA denotes the extremum outside interval.
Standard error in parentheses are the standard errors.
*p < 0.1, **p < 0.05, ***p < 0.01.

Fig. 3D). This suggests the major FR-CFP nexus is curvilinear, positive, and significant. The majority of corporations in the upper Tobin's Q quantiles benefit from FR investment. Long-term, companies whose market-based performance is greater should strive for the maximum FR value to obtain enhanced CFP.

Contrary to existing research that suggests a positive FF-CFP (CCC-CFP) nexus (Chun and Yanbo, 2016; Moussa, 2018; Al-Slehat, 2019; Bilyay-Erdogan, 2020; Baños-Caballero et al., 2020; Lyngstadaas, 2020; Amponsah-Kwatiah and Asiamah, 2021) or a negative FF-CFP (CCC-CFP) nexus (Agha and Faff, 2014; Le, 2019; Ren et al., 2019; Wang et al., 2020; Akgün and Karataş, 2021), this study proposes a concave-convex FR-CFP nexus during COVID-19 periods which is consistent with the TMGT effect and TLGT effect.

Concave FR-CFP relationship in ES firms. The QR results verify that the FR-CFP nexus is an inverted U-shaped (concave) in the lower (10th and 25th), median (50th) and 75th quantiles for the ES firms. Initially, CFP increases as FR increases; however, on surpassing the FR threshold value, CFP decreases as FR increases. This indicates that short-term, the majority of ES companies with lower, median and 75th Tobin's Q quantiles who invest in FR will ensure a higher CFP. In the long run, however, investing in futile FR activities is disadvantageous to CFP. These findings support the TMGT perspective (Trumpp and Guenther, 2017).

The inflection points of 10th, 25th, 50th, and 75th quantiles are 1.078, 1.072, 1.098, and 1.076 respectively (Table 6 and Fig. 4A-D). For the lower, median, and 75th quantiles, the inflection points are greater than the FR sample mean (0.769) and implies most ES firms fall into the FR-low regime. This indicates that the FR-CFP nexus is positive, nonlinear, and significant. Thus, FR investment advantages the majority of ES firms; however, the

appropriate amount of resources required for FR to enhance CFP and stakeholders' expectations should be identified.

Concave-convex FR-CFP relationship in non-ES firms. First, the QR estimation results for the lower (10th and 25th) Tobin's Q quantile companies show that the FR-CFP relationship is concave, which is confirmed by the LDMR. Initially, CFP increases as FR increases; however, on surpassing the FR threshold value, CFP decreases as FR increases. Again, this finding supports the TMGT perspective.

The threshold points of 10th and 25th quantiles are 1.192 and 1.412, respectively (Table 7, Fig. 5A, B). For the lower quantiles, the threshold points are higher than the average of 0.795, indicating most non-ES firms fall into the FR-low regime. Consequently, short-term, the majority of non-ES firms within the lower Tobin's Q quantiles who invest in FR ensure a greater CFP.

Second, the results also confirm the U-shaped (convex) FR-CFP nexus in the upper (75th and 90th) quantiles. Initially, CFP decreases as FR increases; however, on surpassing the FR threshold value, CFP increases as FR increases. This outcome aligns with the TLGT effect.

For the 75th quantile, the optimum FR value (0.511) is below the current average of 0.795, which indicates most non-ES firms are located to the increasing side of the U-shape (Table 7 and Fig. 5C), meaning the major FR-CFP nexus is non-linear, positive, and significant. This suggests that the majority of non-ES corporations in the 75th Tobin's Q quantile benefit from FR investment; however, on a long-term basis, should endeavor to sustain the maximum FR value to ensure enhanced CFP.

For the 90th quantile, the optimal FR value (0.803) is above the current average of 0.795, which indicates most non-ES firms are

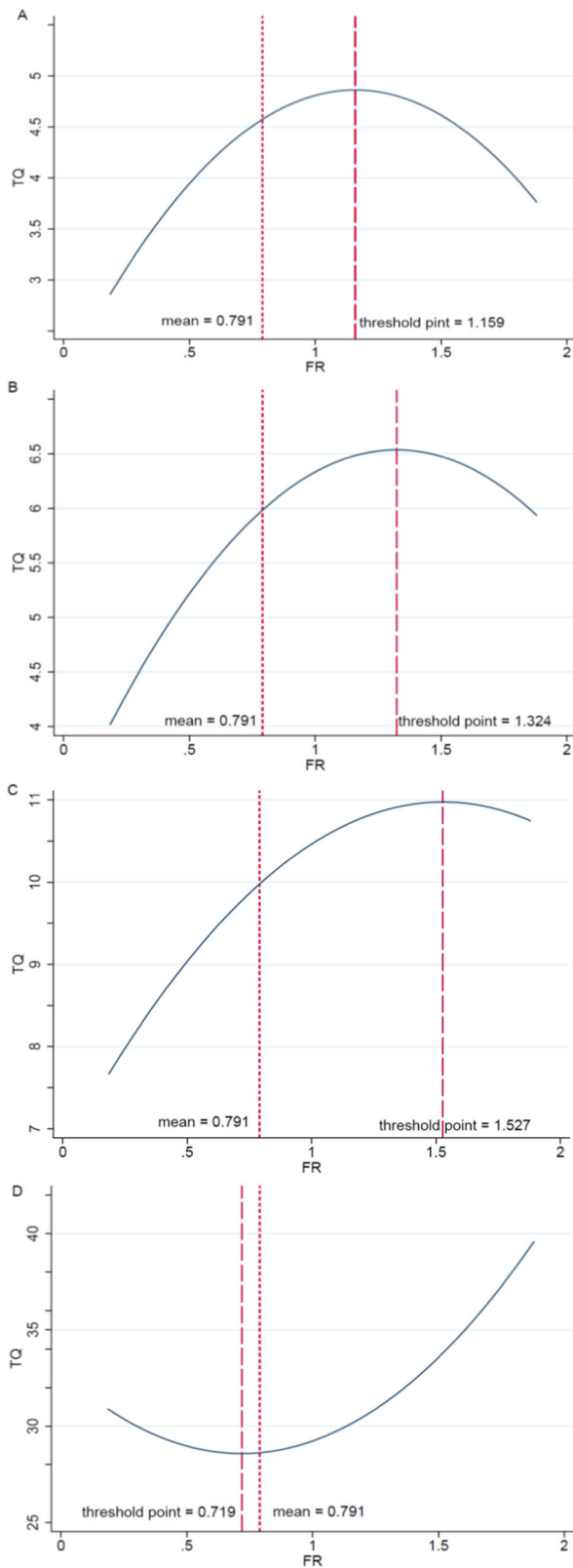


Fig. 3 Concave-convex FR-CFP relationship. This figure illustrates the inverted U-shaped FR-CFP relationship in the 10th quantile (A), 25th quantile (B), and 50th quantile (C), and the U-shaped FR-CFP relationship in the 90th quantile (D).

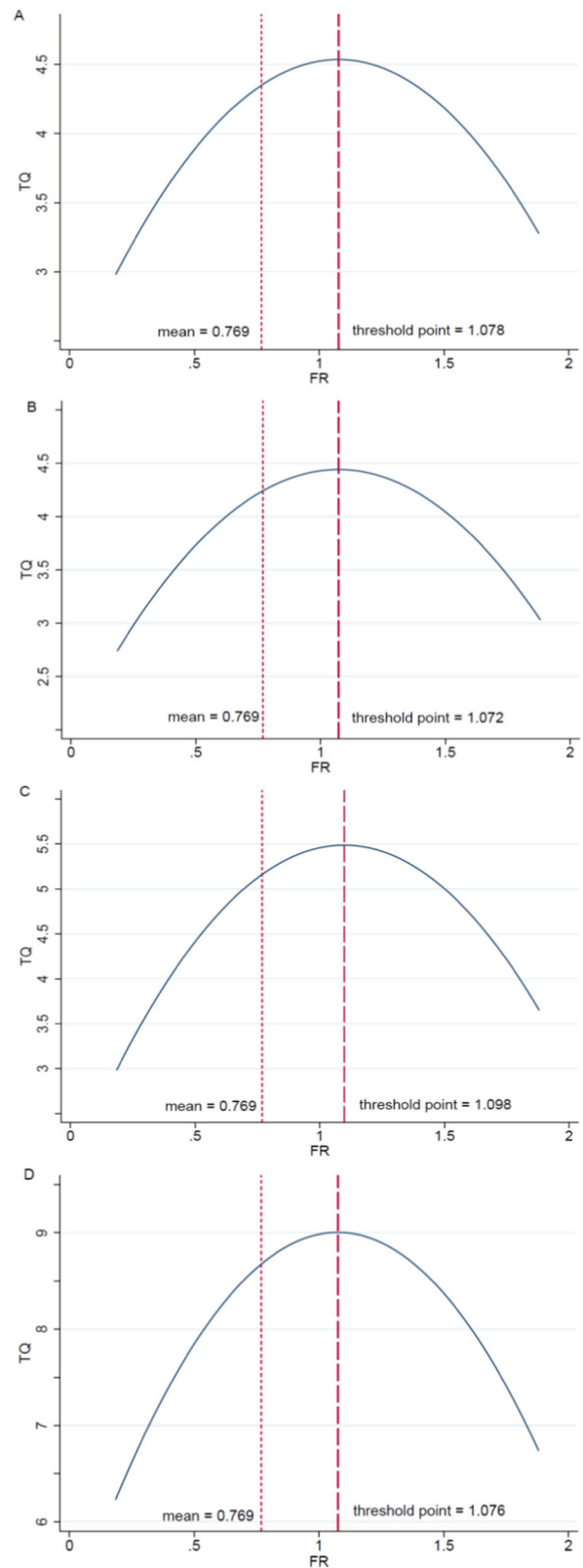


Fig. 4 Concave FR-CFP relationship in the environmentally sensitive firms. This figure illustrates the inverted U-shaped FR-CFP relationship in the 10th quantile (A), 25th quantile (B), 50th quantile (C), and 75th quantile (D).

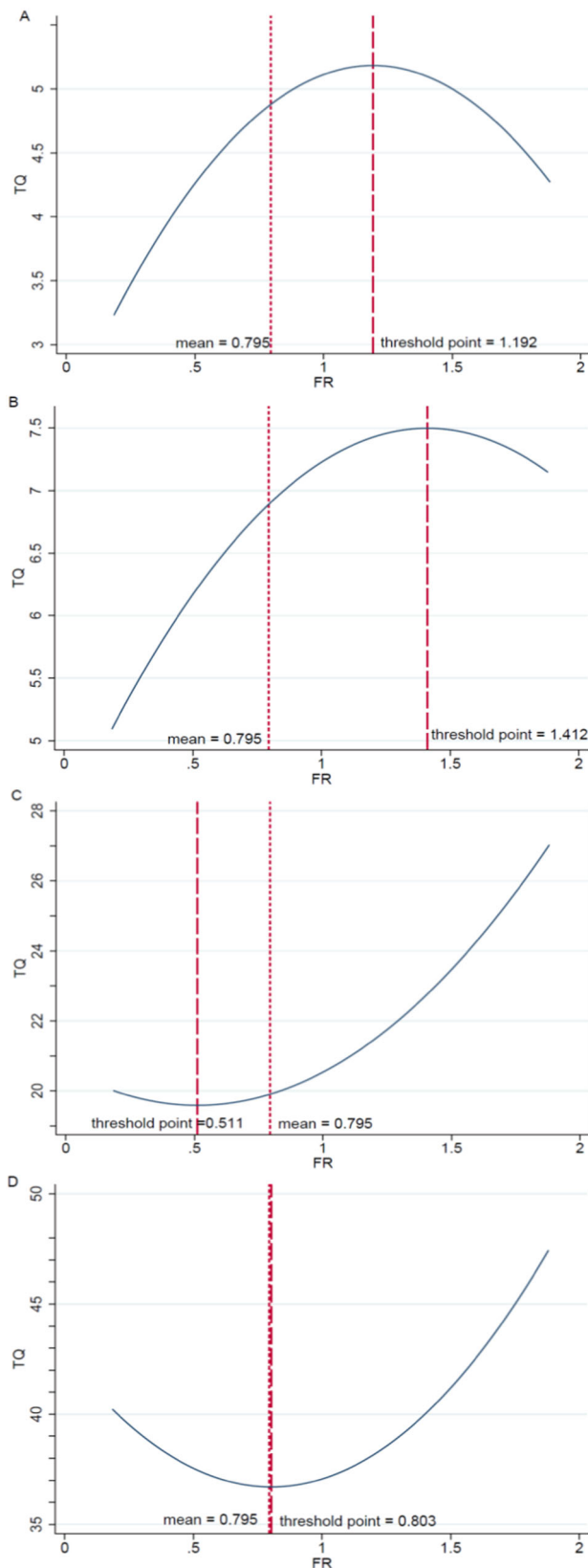


Fig. 5 Concave-convex FR-CFP relationship in the non-environmentally sensitive firms. This figure illustrates the inverted U-shaped FR-CFP relationship in the 10th quantile (A) and 25th quantile (B), and the U-shaped FR-CFP relationship in the 75th quantile (C) and 90th quantile (D).

located to the declining section of the U-shape (Table 7 and Fig. 5D), suggesting the major FR-CFP nexus is non-linear, negative, and significant. This suggests that the majority of non-ES firms in the 90th quantile invest more in FR activities than stakeholders deem necessary.

In summary, non-ES firms with the lower Tobin's Q quantiles should sustain optimal FR value to obtain maximum CFP. Long-term, FR costs outweigh the benefits, which explains the inverted U-shaped FR-CFP nexus. Non-ES corporations in the 75th (90th) Tobin's Q quantiles should pursue greater (less) FR to obtain maximum CFP.

Conclusion

The present article adds to the ongoing literature by assessing the relationship between FR and CFP in Taiwan manufacturing companies using QR approach. The present study fills the gap in existing FR research by proposing a curvilinear (inverted U-shaped) FR-CFP in the lower and median Tobin's Q quantiles firms, and a U-shaped (convex) nexus in the highest (90th quantile) Tobin's Q quantile firms. The relationship between FR and CFP is a curvilinear (either inverted U-shaped or U-shaped pattern), and aligns with the TLGT perspective, TMGT perspective, and the LDMR.

With regard to environmentally sensitive firms, long-term, FR activity costs are greater than any benefit the firm can gain in terms of market-performance. The inverted U-shaped curvilinear nexus implies investment levels into FR must be seriously considered. Although FR can enhance CFP, firms should rationalize FR levels to ensure resources that are no longer increasing stakeholder wealth are identified and managed accordingly.

In the short run, costs of FR activities exceed benefits for environmentally insensitive firms in the higher quantiles. The U-shaped relationship implies environmentally non-sensitive corporations with higher market-performance should maintain the minimum (or maximum) FR value to achieve enhanced CFP. For firms with lower Tobin's Q quantiles, FR activity costs are greater than any advantages obtained long-term, and the inverted U-shaped nexus infers FR investment levels should be considered seriously. For managers, these findings verify that too much or too little FR is not favorable, and optimum FR levels should be confirmed and sustained.

Theoretical implications. The contributions of the study are as follows: (i) Although much research has examined the nexus between FF (or CCC) and CFP in different economies, to the authors' understanding, no prior study has examined the FR-CFP nexus amid the COVID-19 epidemic. Hence, the present study fills the gap in the prior studies and contributes new knowledge and information to this research topic. (ii) This study focuses on the curvilinear nexus between FR and CFP for Taiwanese manufacturing companies during COVID-19 crisis for the first time. (iii) It applies the QR approach for the first time to examine the curvilinear FR-CFP of Taiwanese manufacturing companies. (iv) It also draws on the existing literature on the U-shaped association (Haans et al., 2016; Lind and Mehlum, 2010) for the first time to verify whether the curvilinear FR-CFP nexus actually exists or not.

Managerial implications. This research's empirical findings elicit novel implications. Regarding enterprise, the findings infer manufacturing firms should manage FR activities as effectively as possible. Confirmation of the presence of a curvilinear relationship between FR and CFP suggests that FR can potentially improve CFP. In addition, sufficient cash liquidity and the CCC should be preserved to ensure continued sustainable operation in unpredictable and turbulent economic circumstances.

From policymakers' perspective, as managers should strategically consider investment into FR and how it could improve CFP, the findings argue FR can only serve shareholder interests if the firm's resources are optimally distributed. It is crucial for managers in firms with the lower and median Tobin's Q quantiles to identify the most effective FR contribution amount, as a firm's resources are not limitlessly available. Consequently, managers of firms with lower and median market-based performance should monitor TMGT of FR closely and identify FR's threshold point. This research shows that FR is an effective management tool; however, too many FR activities can reduce the CFP. It is suggested that FR policies are created to enable enterprises to react positively during a crisis or financial distress, such as the pandemic, and maintain an effective investment policy.

From the investors' perspective, the manufacturing industry investment community may use the findings of this research to evaluate investment portfolios. Comparisons can be made of a firm's FR specifically against the proposed optimal points in this research to assess future performance. This information can be used to develop or re-evaluate investment portfolios.

Limitations and future research. Among the limitations of this study, the primary one is the short research period. Further investigation should contain manufacturing industries from several countries, increased observations, and an extended period of study. Second, as there are some other factors that affect CFP during COVID-19 periods, future research can further examine the impact of external environmental opportunities on CFP (e.g., government support for firms to provide employees (labour force)). Lastly, there are also some other strategic choices related to FR mechanisms that affect the level of firm performance, so future research could further discuss the FR-CFP relationships of these mechanisms/channels through the capital channel, the labor channel, or the technology channel.

Data availability

The datasets generated and/or analyzed in the current study are not publicly available as they are based on proprietary data provided by subscription to the Taiwan Economic Journal database (<https://www.finasia.biz>).

Received: 26 March 2023; Accepted: 22 September 2023;

Published online: 06 October 2023

References

- Agha M, Faff R (2014) An investigation of the asymmetric link between credit ratings and corporate financial decisions: "Flicking the switch" with financial flexibility. *J Corp Finance* 29(2):37–57. <https://doi.org/10.1016/j.jcorpfin.2014.08.003>
- Akgün AI, Karataş MA (2021) Investigating the relationship between working capital management and business performance: evidence from the 2008 financial crisis of EU-28. *Int J Manag Finance* 17(4):545–567. <https://doi.org/10.1108/IJMF-08-2019-0294>
- Al-Slehat ZAF (2019) The impact of the financial flexibility on the performance: an empirical study on a sample of Jordanian services sector firms in period (2010–2017). *Int J Bus Manag* 14(16):1–11. <https://doi.org/10.5539/ijbm.v14n6p1>
- Amor-Esteban V, Galindo-Villardón MP, García-Sánchez IM (2018) Useful information for stakeholder engagement: a multivariate proposal of an industrial corporate social responsibility practices index. *Sustain Dev* 26(6):620–637. <https://doi.org/10.1002/sd.1732>
- Amponsah-Kwatiah K, Asiamah M (2021) Working capital management and profitability of listed manufacturing firms in Ghana. *Int J Product Perform Manag* 70(7):1751–1771. <https://doi.org/10.1108/IJPPM-02-2020-0043>
- Anton SG, Nucu AEA (2021) The impact of working capital management on firm profitability: Empirical evidence from the Polish listed firms. *J. Risk Financ. Manag* 14(1):9–23. <https://doi.org/10.3390/jrfm14010009>
- Arslan-Ayaydin Ö, Florackis C, Ozkan A (2014) Financial flexibility, corporate investment and performance: evidence from financial crises. *Rev Quant Finance Account* 42:211–250. <https://doi.org/10.2139/ssrn.1234682>
- Baños-Caballero S, García-Teruel PJ, Martínez-Solano P (2020) Net operating working capital and firm value: a cross-country analysis. *Bus Res Q* 23:234–251. <https://doi.org/10.1177/2340944420941464>
- Barnett ML, Salomon RM (2012) Does it pay to be really good? Addressing the shape of the relationship between social and financial performance. *Strateg Manag J* 33(11):1304–1320. <https://doi.org/10.1002/smj.1980>
- Bilyay-Erdogan S (2020) Does financial flexibility enhance firm value? A comparative study between developed and emerging countries. *Bus: Theory Pract* 22(2):723–736. <https://doi.org/10.3846/btp.2020.12680>
- Brahmana RK, Kontesa M (2021) Does clean technology weaken the environmental impact on the financial performance? Insight from global oil and gas companies. *Bus Strat Env* 30(7):3411–3423. <https://doi.org/10.1002/bse.2810>
- Chambers N, Cifter A (2022) Working capital management and firm performance in the hospitality and tourism industry. *Int J Hosp Manag* 102:103144. <https://doi.org/10.1016/j.ijhm.2022.103144>
- Chancharat N, Kumpamool C (2022) Working capital management, board structure and Tobin's q ratio of Thai listed firms. *Manag Finance* 48(4):541–556. <https://doi.org/10.1108/MF-08-2021-0361>
- Chang BG, Wu KS (2022a) Concave effect of financial flexibility on semiconductor industry performance: quantile regression approach. *Technol Econ Dev Econ* 28(4):948–978. <https://doi.org/10.3846/tede.2022.16622>
- Chang BG, Wu KS (2022b) Convex-concave effect of financial flexibility on hospitality performance: quantile regression approach. *Int J Contemp Hosp* 34(2):687–712. <https://doi.org/10.1108/IJCHM-07-2021-0867>
- Chun MA, Yanbo J (2016) What drives the relationship between financial flexibility and firm performance: Investment scale or investment efficiency? Evidence from China. *Emerg Mark Finance Trade* 52(9):2043–2055. <https://doi.org/10.1080/1540496X.2015.1098036>
- Deloef M (2003) Does working capital management affect profitability of Belgian firms? *J Bus Finance Account* 30(3/4):573–587. <https://doi.org/10.1111/1468-5957.00008>
- Farhan NH, Belhaj FA, Al-ahdal WM, Almaqtari FA (2021) An analysis of working capital management in India: an urgent need to refocus. *Cogent Bus Manag* 8(1):1924930. <https://doi.org/10.1080/23311975.2021.1924930>
- Fieller EC (1954) Some problems in interval estimation. *J R Stat Soc B16*:175–185. <https://doi.org/10.1111/j.2517-6161.1954.tb00159.x>
- Gamba A, Triantis A (2008) The value of financial flexibility. *J Finance* 63:2263–2296. <https://doi.org/10.1111/j.1540-6261.2008.01397.x>
- Goel U, Sharma A (2015) Working capital management efficiency in Indian manufacturing sector: trends and determinants. *Int J Bus Economics Res* 10(1):30–45. <https://doi.org/10.1504/IJEBR.2015.070273>
- Gu Y, Yuan F (2020) Internal control, financial flexibility and corporate performance—Based on empirical analysis of listed companies in information technology industry. *J Phys Conf Ser* 1607:012118. <https://doi.org/10.1088/1742-6596/1607/1/012118>
- Haans RFJ, Pieters C, He ZL (2016) Thinking about U: theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strateg Manag J* 37(7):1177–1195. <https://doi.org/10.1002/smj.2399>
- Hair JF, Hult GTM, Ringle CM, Sarstedt M (2017) A primer on partial Least squares
- Herbert Smith Freehills LLP (2021) Operational resilience: respond, enhance, thrive. Retrieved from <https://www.lexology.com/library/detail.aspx?g=abd502f7-57b8-4c5f-a63c-d8907a60c2ed>. (Accessed on 14 March 2021)
- Jayasinghe M, Selvanathan EA, Selvanathan S (2020) The financial resilience and life satisfaction nexus of indigenous. *Econ Pap* 39(4):336–352. <https://doi.org/10.1111/1759-3441.12296>
- Jensen MC (1986) Agency costs of free cash flow, corporate finance, and takeovers. *Am Econ Rev* 76(2):323–329. <https://doi.org/10.2139/ssrn.99580>
- Kass-Hanna J, Lyons AC, Liu F (2022) Building financial resilience through financial and digital literacy in South Asia and Sub-Saharan Africa. *Emerg Mark Rev* 51:100846. <https://doi.org/10.1016/j.ememar.2021.100846>
- Kayani UN, De Silva TA, Gan C (2021) Corporate governance and working capital management—Inclusive approach for measuring the firm performance. *Rev Pacific Basin Financial Mark Policies* 24:2150015. <https://doi.org/10.1142/S0219091521500156>
- Keskin AI, Dincer B, Dincer C (2020) Exploring the impact of sustainability on corporate financial performance using discriminant analysis. *Sustainability* 12:2346–2360. <https://doi.org/10.3390/su12062346>
- Koenker R, Bassett G (1978) Regression quantiles. *Econometrica* 46(1):33–50. <https://doi.org/10.2307/1913643>
- Laghari F, Chengang Y (2019) Investment in working capital and financial constraints: empirical evidence on corporate performance. *Int J Manag Finance* 15:164–190. <https://doi.org/10.1108/IJMF-10-2017-0236>

- Le B (2019) Working capital management and firm's valuation, profitability and risk evidence from a developing market. *Int J Manag Finance* 15:191–204. <https://doi.org/10.1108/IJMF-01-2018-0012>
- Lin Q, Wang Y (2021) Working capital management, the market environment and corporate performance: evidence from China. *Appl Econ* 53:1–12. <https://doi.org/10.1080/00036846.2021.1904120>
- Lind JT, Mehlum H (2010) With or without U? The appropriate test for a U-shaped relationship. *Oxf Bull Econ Stat* 72(1):109–118. <https://doi.org/10.1111/j.1468-0084.2009.00569.x>
- Lu J, Rodenburg K, Foti L, Pegoraro A (2022) Are firms with better sustainability performance more resilient during crises? *Bus Strat Env* 31:3354–3370. <https://doi.org/10.1002/bse.3088>
- Lyngstadaas H (2020) Packages or systems? Working capital management and financial performance among listed U.S. manufacturing firms. *J Manag Control* 31:403–450. <https://doi.org/10.1007/s00187-020-00306-z>
- Mahmood F, Han D, Ali N, Mubeen R, Shahzad U (2019) Moderating effects of firm size and leverage on the working capital finance–profitability relationship: evidence from China. *Sustainability* 11:2029. <https://doi.org/10.3390/su11072029>
- Maiti M (2021) Quantile regression, asset pricing and investment decision. *IIMB Manag Rev* 33:28–37. <https://doi.org/10.1016/j.iimb.2021.03.005>
- Marchica MT, Mura R (2010) Financial flexibility, investment ability, and firm value: Evidence from firms with spare debt capacity. *Financ Manage* 39:1339–1365. <https://doi.org/10.1111/j.1755-053X.2010.01115.x>
- McKnight A, Rucci M (2020) The financial resilience of households: 22 country study with new estimates, breakdowns by household characteristics and a review of policy options. Centre for Analysis of Social Exclusion, London School of Economics
- Moussa AA (2018) The impact of working capital management on firms' performance and value: Evidence from Egypt. *J Asset Manag* 19:259–273. <https://doi.org/10.1057/s41260-018-0081-z>
- Muir K, Reeve R, Connolly C, Marjolin A, Salignac F, Ho K (2016) Financial resilience in Australia 2015. Centre for Social Impact - University of New South Wales, for National Australia Bank
- Nkundabanyanga SK, Mugumya E, Nalukenge I, Muhwezi M, Najjemba GM (2019) Firm characteristics, innovation, financial resilience and survival of financial institutions. *J Account Emerg Econ* 10(1):48–73. <https://doi.org/10.1108/JAEE-08-2018-0094>
- Pierce JR, Aguinis H (2013) The too-much-of-a-good-thing effect in management. *J Manage* 39:313–338. <https://doi.org/10.1177/0149206311410060>
- Prasad P, Narayanasamy S, Paul S, Chattopadhyay S, Saravanan P (2019) Review of literature on working capital management and future research agenda. *J Econ Surv* 33(3):827–861. <https://doi.org/10.1111/joes.12299>
- Ren T, Liu N, Yang H, Xiao Y, Hu Y (2019) Working capital management and firm performance in China. *Asian Rev Account* 27(4):546–562. <https://doi.org/10.1108/ARA-04-2018-0099>
- Rezaei Soufi H, Esfahanipour A, Akbarpour Shirazi M (2023) A quantitative measure for financial resilience of firms: evidence from Tehran stock exchange. *Sci Iran* 30(1):302–317. <https://doi.org/10.24200/sci.2021.55845.4433>
- Sakyi-Nyarko C, Ahmad AH, Green CJ (2022) The gender-differential effect of financial inclusion on household financial resilience. *J Dev Stud* 58(4):692–712. <https://doi.org/10.1080/00220388.2021.2013467>
- Salignac F, Marjolin A, Reeve R, Muir K (2019) Conceptualizing and measuring financial resilience: a multidimensional framework. *Soc Indic Res* 145:17–38. <https://doi.org/10.1007/s11205-019-02100-4>
- Salignac F, Hanoteau J, Ramia I (2022) Financial resilience: a way forward towards economic development in developing countries. *Soc Indic Res* 160:1–33. <https://doi.org/10.1007/s11205-021-02793-6>
- Sharma RK, Bakshi A (2019) An evident prescience of determinants of dividend policy of Indian real estate companies: an empirical analysis using co-integration regression and generalised method of moments. *J Financ Manag Prop Constr* 24(3):358–384. <https://doi.org/10.1108/JFMPC-02-2019-0012>
- Taylor M (2013) Securing resilience. Scottish Federation of Housing Associations Finance Conference. Perthshire
- Teng X, Chang BG, Wu KS (2021) The role of financial flexibility on enterprise sustainable development during the COVID-19 crisis—A consideration of tangible assets. *Sustainability* 13:1245–1261. <https://doi.org/10.3390/su13031245>
- Trumpp C, Guenther T (2017) Too little or too much? Exploring U-shaped relationships between corporate environmental performance and corporate financial performance. *Bus Strategy Environ* 26(1):49–68. <https://doi.org/10.1002/bse.1900>
- Wang Z, Akbar M, Akbar A (2020) The interplay between working capital management and a firm's financial performance across the corporate life cycle. *Sustainability* 12(4):1661. <https://doi.org/10.3390/su12041661>
- Yeon J, Lin MS, Lee S, Sharma A (2021) Does family matter? The moderating role of family involvement on the relationship between CSR and firm performance. *Int J Contemp Hosp Manag* 33(10):3729–3751. <https://doi.org/10.1108/IJCHM-03-2021-0315>
- Yi J (2020) Financial flexibility, dynamic capabilities, and the performance of manufacturing enterprises. *J Res Emerg Mark* 2(2):19–32. <https://doi.org/10.30585/jrems.v2i2.465>
- Yoon B, Lee JH, Ryan B (2018) Does ESG performance enhance firm value? Evidence from Korea. *Sustainability* 10(10):3635. <https://doi.org/10.3390/su10103635>
- Yao R, Xu Y, Zhang J (2023) Financial resilience of two-worker households from a health perspective. *J Consum Aff*, 1–23. In press. <https://doi.org/10.1111/joca.12525>
- Zhang X, Chang BG, Wu KS (2022) COVID-19 shock, financial flexibility, and hotels' performance nexus. *Front Public Health* 10:792946. <https://doi.org/10.3389/fpubh.2022.792946>

Author contributions

ZX: conceptualization, writing—original draft, interpretation of the results, validation, and supervision. Wu, KS: conceptualization, data curation, methodology, formal analysis, writing—original draft, and writing—review and editing. HM: assisted in writing the manuscript, validation, project administration, resources, visualization. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants or animals conducted by any of the authors.

Informed consent

This paper does not provide any studies with human participants conducted by any of the authors.

Additional information

Correspondence and requests for materials should be addressed to Kun-Shan Wu.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2023