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The impact of working capital management on credit rating

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Abstract

This study investigates the possible nonlinear relationship between working capital and credit rating. Furthermore, it examines the relationship between the three components of working capital (inventory, accounts receivable, and accounts payable) and a firm's credit rating. Employing data for U.S listed firms for the period between 1985 and 2017, the results of our ordered probit model show a nonlinear relationship between working capital and its components and credit rating. Finally, we find that the deviation from the optimal working capital adversely affects the credit rating. The results of this study are of significant importance for policy makers, managers, decision makers, and credit-rating agencies, as they help highlight the importance of working capital management for a firm's credit rating.

Keywords: Credit rating, Working capital management, Finance, Investment, Trade credit

JEL Classification: G1, G12, G31, G33

Introduction

In light of the 2008 financial crisis, credit-rating scores (CRSs) released by credit-rating agencies have grown in importance (Hung et al. 2017). Credit-rating agencies play a vital role in capital markets by reducing the moral hazard problem. In addition, credit ratings help investors assess the creditworthiness of issuers and the financial securities issued by them (Lee et al. 2021). Furthermore, credit ratings are used as a benchmark based on which investors manage their portfolios. Finally, they play an important monitoring role, as they may require firms with rating deteriorations to take corrective actions to minimize these deteriorations (Huan and Mohamed 2021). Additionally, CRSs have become a crucial tool that helps investors in their investment decision-making process, as they help investors identify risky assets, price their credit, and allocate their capital more efficiently (Amato and Furfine 2004). Investors are highly concerned about borrowers' ability to fulfil their obligations (Haspolat 2015). Moreover, Bauer and Esqueda (2017) point out that banks rely on credit rating scales to compensate for information deficits when making loan decisions. Thus, a considerable amount of literature has been published on the impact of factors such as firm-specific characteristics [Return on Assets (ROA), size, and liquidity], corporate social responsibility (CSR), and operational leanness on the corporate credit rating (Attig et al. 2013; Hung et al. 2013; Bendig et al. 2017; Dong et al. 2021). However, to our knowledge, no previous study has investigated the impact of working capital management (WCM) on a firm's credit rating. A key aspect of a WCM decision is its impact on a firm's risk, return, and valuation (Smith 1980). Many researchers have attempted to investigate the impact of WCM on firms' financial performance (e.g., Aktas et al. 2015; Jose et al. 1996; Shin and Soenen 1998; Deloof 2003; García-Teruel and Martínez-Solano 2007). These studies have mainly focused on the impact of WCM on a firm's profitability performance. The interesting point here is the consensus that maintaining a high level of net working capital (NWC) reduces a firm's risk and profitability.

The results of these previous studies led us to take the research on this topic a step further and investigate the impact of WCM on a firm's credit rating. Understanding this relationship is of high importance for corporate managers in their quest for external financing, especially after the 2008 financial crisis (Hung et al. 2013).

One would expect that maintaining a high level of working capital would enhance a company's credit rating since it reduces risk. However, is this always the case? Besides reducing risk, previous studies have shown that holding a high level of working capital reduces profits. This particular observation raises a major concern about the effect of low profits on a company's ability to cover interest payments, especially since a company's reliance on external financing would increase as the level of working capital increases (Kieschnick et al. 2013). This concern may indicate that maintaining a high level of working capital may enhance a company's credit rating for a certain period but become harmful thereafter. This argument suggests a concave relationship between WCM and credit rating. Furthermore, this concave relationship postulates that firms could have an optimal working capital ratio to reduce risks and improve credit ratings. Therefore, we expect a positive or negative deviation from the optimal working capital to have an adverse effect on the evaluation of a firm's risk and ultimately impact the firm's credit rating.

To this end, this study distinguishes itself from previous studies in the following aspects: first, it examines the possible concave relationship between WCM and credit rating; second, it conducts a deeper analysis by investigating the impact of three important components of working capital, namely inventory (INV), accounts receivable (AR), and accounts payable (AP), on a firm's credit rating; and finally, it investigates the impact of deviation from the optimal working capital on a firm's credit rating. This study attempts to answer the following questions: (1) Does WCM and its components affect the credit rating? (2) If so, what is the nature of this relationship? Finally, (3) does deviation from optimal working capital affect a firm's credit rating?

Center for research in security prices

Utilizing annual panel data of U.S. listed firms from Wharton Research Data Services (WRDS) merged with Center for Research in Security Prices (CRSP)/Compustat files for the period between 1985 and 2017, we find evidence to draw the following conclusions. First, there exists a positive relationship between WCM and credit rating. Second, we find that high investments in working capital have an inverse impact on CRSs; thus, our results support the non-linear relationship between WCM and credit rating. Third, there exists a nonlinear relationship between the components of working capital (inventory and accounts receivable) and CRSs, while accounts payable have a negative relationship with credit scoring. Finally, the results show that firms have an optimal level of working capital and deviation from this target harms their credit rating.

The rest of this paper is organized as follows: "Literature review and hypotheses development" section discusses previous studies on WCM and credit ratings; "Methodology" section presents the study methodology and research design; "Data and descriptive statistics" section presents the data and descriptive statistics sample and data resources; "Empirical results" section presents the empirical results; and "Concluding remarks" section concludes the paper.

Literature review and hypotheses development

In this section, we discuss the relevant literature on WCM and credit ratings, in addition to the development of the research hypotheses.

Working-capital management

According to Lewellen et al. (1980), decisions regarding working capital have no impact on a firm's value in a perfect capital market. However, because of the nonexistence of a perfect capital market and the presence of an optimal level of each component of working capital, such as accounts receivable (Nadiri 1969; Emery 1984), inventories (Ouyang et al. 2005), and accounts payable (Nadiri 1969; Abuhommous 2017), one would expect firms to have a target or optimal level of working capital. Aktas et al. (2015) provide evidence for the presence of an optimal level of working capital.

The WCM concept pertains to how firms manage their current assets and liabilities, and this policy comprises two elements: (1) the level of investment in current assets and (2) the means of financing current assets. When selecting the most suitable policy, firms try to obtain an optimal level of working capital, depending on the trade-off between risk and return.

Focusing on the second element, firms may adopt one of three working capital strategies, namely that of a conservative, hedging, or aggressive strategy. In the conservative approach, firms try to maintain high levels of working capital (high investment in working capital), as they rely more on long-term financing compared with short-term financing. This strategy decreases both the risk and return of the firm due to the higher need for expensive external financing, which harms the firm's profitability. In this regard, Baños-Caballero et al. (2014) state that a low level of working capital enhances a firm's performance because of the lower need for expensive external financing. Furthermore, an increase in working capital may result in an increase in the opportunity cost of cash locked-up in accounts receivable and inventories (Tauringana and Afrifa 2013). However, a firm may adopt an aggressive working capital strategy by using more short-term sources of funds to finance its investments, which indicates low investment in working capital. By adopting such a strategy, both risk and returns increase. Finally, in the hedging strategy (matching strategy), the temporary amount of short-term assets is met with short-term financing, and the permanent amount of short-term assets is financed by long-term financing resources; thus, the investment in working capital may increase or decrease according to the firm's activity.

Several attempts to investigate the impact of WCM on a firm's profitability (e.g., Jose et al. 1996; Shin and Soenen 1998; Deloof 2003; García-Teruel and Martínez-Solano 2007) suggest that there exists a linear relationship between a firm's investment in working capital and its profitability. The findings of such studies indicate that the lower the investment in working capital, the higher the profitability. Mohamad and Saad (2010) find a negative impact of working capital elements, such as cash conversion cycles (CCCs), current ratios, current-asset-to-total-asset ratios, current-liabilities-to-total-asset ratios, and debt-to-asset ratios, on firm performance, suggesting the importance of WCM in enhancing performance at both the accounting and market levels.

Kieschnick et al. (2013) investigate the relationship between net operating WCM and firm value. They find that for average firms, every additional dollar held in cash is worth more for shareholders than investing that dollar in net operating working capital. They add that, for the average firm, investing more in trade credit would add more value for shareholders than investing in inventory, which indicates the high importance of trade credit as part of WCM for shareholder wealth. In a more recent study, Aktas et al. (2015) document a nonlinear relationship between excess NWC and stock performance, finding that this relationship is negative for firms with positive excess NWC and positive for firms with negative excess NWC. These findings further support the idea of an optimal level of NWC, and firms that reach that level increase their stock value.

Another stream of research has focused on the impact of WCM on firm risk. For instance, maintaining a high working capital might lead a firm to rely more on long-term financing, which would result in a higher interest cost. Moreover, high working capital increases a firm's opportunity cost (Kieschnick et al. 2013). On the other hand, adopting excessively aggressive WCM may increase the risk of stockouts, input price fluctuations, and supply costs (e.g., Blinder and Maccini 1991; Fazzari and Petersen 1993; Corsten and Gruen 2004). Therefore, the negative relationship between NWC and firm performance may be due to an increase in firm risk following a decrease in NWC.

Credit rating

A firm's credit rating is a statistic that summarizes a firm's creditworthiness by considering several elements of the firm's financial characteristics, such as debt ratio, priority and maturity structure of the firm's debt, and the volatility of the firm's cash flows (Bali and Hovakimian 2009).

The corporate credit rating has grown in importance especially after the 2008 financial crisis (Hung et al. 2013). Therefore, Amato and Furfine (2004) assert the important role of credit rating analysis in financing and investment decisions, such as in pricing credit, determining risky assets, and asset allocation. Furthermore, investors are highly concerned about borrowers' ability to fulfil their obligations (Haspolat 2015). In this regard, Bauer and Esqueda (2017) point out the importance of credit rating scales in helping banks overcome information deficits when making loan decisions.

A considerable amount of the literature has been published on firms' credit ratings. These studies can be classified into two streams. The first stream includes studies on the factors that influence the credit rating. The second concerns the impact of the credit rating on a firm's decision-making. Attig et al. (2013) study the impact of CSR on a firm's credit rating and find that firms with good social performance are rated relatively high.

They also conclude that CSR investments can reduce financing costs owing to high credit ratings. Hung et al. (2013) offer evidence on the effect of firm-specific characteristics on the credit rating and find that ROA, size, Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA), and interest coverage are positively related to credit rating. However, the debt ratio and ratio of cash to current liabilities are negatively related to credit rating. In a large longitudinal study, Bendig et al. (2017) investigate the impact of operational leanness [relative inventory leanness and relative property, plant, and equipment (PPE) leanness] on a firm's credit rating and find a concave positive relationship between inventory leanness and credit rating and a negative and concave relationship between PPE leanness and credit rating.

Turning to the impact of a firm's credit rating on decision-making, Kisgen (2006) examine the relationship between credit ratings and capital structure decisions. He finds a negative relationship between a change in credit rating status and reliance on debt. As firms near a change in credit rating status (upgrade or downgrade), their reliance on debt decreases. Another study finds that firms pursue real earnings management activities when they have an upcoming credit rating change; however, just prior to the change, they reduce their discretionary accruals. Moreover, the study concludes that real activities management and credit rating upgrades are positively related, whereas there is no significant relationship between real activities management and credit rating downgrades (Kim et al. 2013).

Credit rating and WCM

Since 1941, the Standard & Poor's (S&P) rating agency has assigned its CRSs based on two broad categories of risk: financial risk and business risk. In the business risk category, S&P is concerned with the firm's ability to generate sufficient cash flow to cover operating revenues. However, in the financial risk category, the focus is on the firm's ability to manage its financial leverage and debt.

As mentioned earlier, maintaining high levels of working capital reduces a firm's risk and returns. To this point, one would expect that firms with high levels of working capital would have higher CRSs because of the low risk of such firms. However, considering the above two risk categories may change the rules. For instance, Baños-Caballero et al. (2012) suggest that excessive investment in working capital may negatively impact a firm's operating performance, consequently reducing the firm's cash inflows (Deloof 2003; García Teruel and Martínez-Solano 2007; Shin and Soenen 1998). Such studies conclude that reducing the CCC and inventory amount would lead to higher operating performance. Thus, over time, firms that suffer a decrease in their operating performance due to their high levels of working capital would be less able to repay interest payments. Kieschnick et al. (2013) suggest that these payments would be high for firms with high levels of working capital due to their high reliance on external financing, which would lead to higher bankruptcy costs according to Kieschnick et al. (2013). This may result in lower CRSs for such firms. Shin and Soenen (1998) report a good example on this point: They mention that despite the similarity of two firms in capital structure, namely Kmart and Walmart, Kmart faced higher financial troubles than Walmart due to its high NWC relative to sales, which led Kmart to close 110 stores in 1994, and in 2002 the firm filed for Chapter 11 bankruptcy protection. This example supports the argument that the relationship between working capital level and credit rating is concave. To this end, one may expect that neither over-investment in working capital nor an aggressive working capital policy would be favorable for a firm's credit rating. This is because increasing investment in working capital is preferable for credit rating (due to its role in reducing risk) to some point, after which the rating starts to drop (due to its negative impact on cash flows). Consequently, we hypothesize a concave relationship between WCM and credit rating.

Furthermore, the above discussion leads to the conception that firms should efficiently manage their working capital by maintaining it at an optimal level. According to Gill et al. (2019), efficient WCM positively impacts the bond quality rating. Therefore, we conjecture that holding working capital on target enhances a firm's credit rating.

Methodology

In "Estimation framework" section, we develop a regression model to examine whether WCM affects credit rating decisions. In "The concave relationship between NWC and credit rating" and "Components of working capital and credit rating" sections, we expand our analysis to examine the nonlinear relationship between the working capital level and its components (i.e., accounts receivable, inventory, and accounts payable) and credit rating. In the final section of the analysis, we attempt to determine the optimal working capital level and examine whether deviation from the optimal working capital adversely affects the credit rating score.

Estimation framework

In this section, we augment the previous models of Ashbaugh-Skaife et al. (2006), Alissa et al. (2013), Attig et al. (2013), Oikonomou et al. (2014), and Bendig et al. (2017) by including our main independent variable (WCM) in the credit rating model. We use an ordered probit regression, where we add the working capital proxy to the model, as follows:

$$\begin{aligned} RATING_{i,t} = a_{i,t} &+ \beta_1 NWC_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 LEV_{i,t} + \beta_4 COVERAGE_{i,t} \\ &+ \beta_5 LOSS_{i,t} + \beta_6 CAP\_INTEN_{i,t} + \beta_7 SUBORD_{i,t} + \beta_8 BIG4_{i,t} \\ &+ IndustryEffects_{i,t} + YearEffects_t + \varepsilon_{i,t} \end{aligned} \quad (1)$$

where RATING is the S&P credit rating for firm *i* at time *t*. We consider the following to be determinants of credit rating: NWC ratio, log of assets, firm's leverage, interest coverage ratio, whether the firm has losses (indicated by a dummy variable), whether the firm has fixed assets in its asset structure (measured by capital intensity), whether the firm has subordinate loans, and whether the firm's external auditor is considered as one of the "big four" auditing firms (indicated by a dummy variable). We present the definitions of these variables in Table 2. We also include *IndustryEffects* to control for differences across industries and *YearEffects* to control for the time-specific effect, which captures economic factors that affect all firms in the same year but vary over time, and $\varepsilon_{i,t}$ is the error term.

Table 1 Credit rating distribution

S&P credit rating	RATING	MICRORATING	No. of firm-years observations	Percentage of total observations (%)
AAA	8	20	571	1.32
AA+	7	19	257	0.60
AA	7	18	1022	2.37
AA−	7	17	1203	2.79
A+	6	16	1949	4.51
A	6	15	3157	7.31
A−	6	14	2964	6.86
BBB+	5	13	3630	8.41
BBB	5	12	4507	10.44
BBB−	5	11	3197	7.40
BB+	4	10	2294	5.31
BB	4	9	3275	7.58
BB−	4	8	4188	9.70
B+	3	7	5265	12.19
B	3	6	3125	7.24
B−	3	5	1503	3.48
CCC+	2	4	570	1.32
CCC	2	3	288	0.67
CCC−	2	2	120	0.28
CC	1	1	98	0.23
Total			43,183	100

The statistics in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

Key variables measurement

In this section, we present the key variables included in the estimated model, including their definitions and measurement.

Dependent variable (credit rating)

Credit ratings are based on opinions about credit risk and are considered a quantified forward-looking assessment of the debt issuer's creditworthiness, which measures firm's ability to meet its financial commitment in terms of time and fullness. They can also be used to measure the likelihood of default and can thus be assigned to individual debt issues or, as an overall credit rating, to corporations, governments, and municipalities, or to a sovereign government (Standard and Poor's 2022). Following the literature (e.g., Kisgen 2009, 2006; Hovakimian and Li 2009; Alissa et al. 2013) we use Standard & Poor's Long-Term Domestic Issuer Credit Rating (RATING), a long-term scale for firms according to their overall creditworthiness, in which the rating range is assigned from "AAA" for an extremely strong obligor (highest rating) to "D" for an obligor in default (lowest rating). Consistent with Attig et al. (2013) and Bendig et al. (2017), we transform the credit rating to an ordinal scale for the purpose of our regression. Thus, we assign eight values starting from one for a "CC" rating to eight for an "AAA" rating (see Table 1). As a robustness check, we follow Alissa et al. (2013)

and Bendig et al. (2017), who measure credit rating based on 20 micro rating classes. We calculate MICRORATING and transform credit rating to an ordinal scale with 20 categories, ranging from the value of 1 for the "CC" class to 20 for the "AAA" class.[1] Table 1 reports the number of firm-year observations for each credit-rating category. The number of firms per year ranges from 98 to 5265 (Table 2).

Main independent variable (WCM)

Our main independent variable that measures a firm's WCM investment is based on the literature (e.g., Shin and Soenen 1998; Aktas et al. 2015; Kieschnick et al. 2013). Following these works, we use the net operating working capital to sales ratio (NWC); the dependent variable is measured as (INV) plus (AR) minus (AP), all divided by total sales. Furthermore, as a robustness check, we follow Baños-Caballero et al. (2012) and measure working capital policy as (inventory/cost of sales) × 365 + (accounts receivable/sales) × 365 − (accounts payable/cost of sales) × 365; we call this the CCC.

Control variables and firms' characteristics

A firm's characteristics are included in the credit rating regression model, based on the literature (e.g., Ashbaugh-Skaife et al. 2006; Kisgen 2006; Bendig et al. 2017; Alissa et al. 2013; Attig et al. 2013). With respect to firm size (SIZE), we expect large firms to have more leverage because of the high volume of information available about the firm; usually, large firms tend to have less asymmetric information in the market. We use the natural logarithm of total assets to measure size. Therefore, larger firms are expected to have higher credit ratings than smaller firms. Firm's leverage (LEV) has an inverse relationship with credit rating, since firms with high leverage are more likely to suffer from financial crises and bankruptcy probability increases. We use the ratio of long-term debt-to-total-assets as an indicator of a firm's leverage. Interest coverage ratio (COVERAGE) is used as a proxy for a firm's default risk, which demonstrates a firm's ability to pay its debt interest; the more able the firm is to pay its debt interest, the more likely the firm will receive a higher credit rating. This ratio is calculated by dividing the operating income before depreciation by interest expenses. A firm's losses (LOSS) are an indicator of the firm's likelihood of default; unprofitable firms tend to have a high probability of bankruptcy and therefore have a lower credit rating. Firm's capital intensity (CAP_INTEN) is included as a control variable because firms with high capital intensity present a lower risk for debt providers; thus, firms with high capital intensity are expected to have a higher credit rating. This variable is measured using the ratio of property, plant, and equipment to total assets. Subordinate debt (SUBORD) is included as a control variable to capture the differences in firms' debt structure; firms with a debt structure that includes subordinated debt are considered riskier and are expected to have a lower credit rating. Bendig et al. (2017), Ashbaugh-Skaife et al. (2006), and Alali et al. (2012) find an inverse relationship between subordinate debt and credit rating. We measure subordinate debt using a dummy variable that takes the value of one if the firm has subordinate debt and zero otherwise. We also include external auditors to control

[1] We also include "D" credit rating firms in our regression; the results are qualitatively similar.

Table 2 Variables definition

Variables definition	Acronym	Definition	Predicted signs	Relevant literature
Dependent variables				
Credit rating	RATING	Ordinal scale of 8 categories, values starting from 1 for 'CC' to 8 for 'AAA' rating		Kisgen (2006), Ashbaugh-Skaife et al. (2006), Attig et al. (2013), Bendig et al. (2017)
	MICRORATING	Ordinal scale of 20 categories, ranging from 1 for 'CC' to 20 for 'AAA' class		Kisgen (2006), Attig et al. (2013), Bendig et al. (2017), Alissa et al. (2013)
Explanatory variables				
Operating working capital	NWC	Trade credit accounts receivable + inventory − accounts payable all divided by total sales	+	Aktas et al. (2015)
Cash conversion cycle	CCC	(inventory/cost of sales) × 365 + (accounts receivable/sales) × 365 − (accounts payable/cost of sales) × 365	+	Baños-Caballero et al. (2014)
Accounts receivable	AR	Accounts receivable/sales	+	Aktas et al. (2015)
Inventory	INV	Inventory/cost of sales	+	Aktas et al. (2015)
Accounts payable	AP	Accounts payable/cost of sales	−	Aktas et al. (2015)
Control variables				
Firm size	SIZE	Natural logarithm of total assets	+	Ashbaugh-Skaife et al. (2006), Alissa et al. (2013), Attig et al. (2013), Bendig et al. (2017), Dong et al. (2021)
Financial leverage	LEV	Total debt/total assets	−	Ashbaugh-Skaife et al. (2006), Attig et al. (2013), Bendig et al. (2017)
Interest coverage ratio	COVERAGE	Operating income before depreciation divided by total interest expenses	+	Ashbaugh-Skaife et al. (2006), Attig et al. (2013), Bendig et al. (2017)
Firm's loss	LOSS	1 if the firm has a negative net income for the current year and for the previous year as well, and 0 otherwise	−	Ashbaugh-Skaife et al. (2006), Attig et al. (2013), Bendig et al. (2017)
Subordinate debt	SUBORD	Binary variable that takes the value of 1 if the firm has subordinate debt, and 0 otherwise	−	Ashbaugh-Skaife et al. (2006), Bendig et al. (2017)
Capital intensity	CAP_INTEN	Gross property, plant, and equipment divided by total firm assets	+	Ashbaugh-Skaife et al. (2006), Alissa et al. (2013), Attig et al. (2013), Bendig et al. (2017)
Rank of auditing firm	BIG4	Binary variable takes the value of 1 if the firm's external auditor is ranked as one of the biggest four accounting firms, and 0 otherwise	+	Attig et al. (2013) Bhandari and Golden (2021)

Table 3 Descriptive statistics of explanatory and control variables

Variables	Mean	Median	S.D	5%	95%
RATING	3.58	4	1.319	2	6
MICRORATING	9.74	10	3.83	4	16
NWC	0.153	0.132	0.181	−0.015	0.392
CCC	56.94	47.706	94.11	−40.155	195.31
AR	51.67	47.037	43.339	5.322	102.41
INV	60.957	44.068	70.667	0	175.059
AP	55.613	41.726	64.976	12.324	134.538
SIZE	7.877	7.797	1.618	5.348	10.65
LEV	0.333	0.297	0.201	0.054	0.777
COVERAGE	7.626	4.946	7.674	0.585	29.656
LOSS	0.164	0	0.37	0	1
SUBORD	0.005	0	0.07	0	0
CAP_INTEN	0.707	0.658	0.45	0.106	1.421
BIG4	0.527	1	0.499	0	1

Variables definitions are provided in Table 2. The statistics in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

for their role in monitoring a firm's actions (Alissa et al. 2013); BIG4 is the variable used as a proxy for corporate governance, which reduces opportunistic managerial behavior (Bhandari and Golden 2021).

Data and descriptive statistics

This section presents the details of the selection criteria and sample descriptive statistics. Our sample is drawn from the population of U.S. listed firms, and to serve our study aim, we select firms that have a credit rating. Thus, we exclude any firms with missing values for credit rating or working capital. Consistent with previous studies (e.g., Hovakimian and Li 2009; Attig et al. 2013; Bendig et al. 2017), this study utilizes annual panel data of listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017.[2] Following the literature, we exclude firms with a standard industry classification (SIC) code between 6000 and 6799. Thus, we exclude all firms operating in the financial sectors. All firms should have positive total assets and net sales, because these variables are used to deflate other variables, and the results may not be consistent when they have negative or zero values. We also only consider observations without missing values. These criteria yield 43,183 firm-year observations.

Summary statistics

Table 3 presents the descriptive statistics for the explanatory and control variables. The NWC cycle has a mean of 56.94 days, while the median is 47.70 days. The financial leverage to total assets ratio is on average 33.3% (the median is 29.7%). For unreported data, the number of firm-year observations in which the external auditor ranks among the "big four" (BIG4) accounting firms is 31,603. The total number of firm-year observations for reported loss is 9,955.

[2] Compustat cover credit ratings from the year 1985 onwards.

Table 4 Correlation matrix

	RATING	MICRO-RATING	NWC	SIZE	COVERAGE	LEV	CAP_INTEN	LOSS	BIG4	SUBORD
RATING	1									
MICRO-RATING	0.979	1								
NWC	0.008	0.009	1							
SIZE	0.51	0.511	− 0.004	1						
COVERAGE	0.425	0.432	0.015	0.304	1					
LEV	− 0.503	− 0.507	− 0.031	− 0.332	− 0.536	1				
CAP_INTEN	0.179	0.182	− 0.053	0.059	− 0.07	0.019	1			
LOSS	− 0.409	− 0.419	− 0.015	− 0.212	− 0.333	0.307	− 0.031	1		
BIG4	− 0.006	− 0.001	− 0.01	− 0.059	− 0.015	0.015	0.008	− 0.006	1	
SUBORD	− 0.045	− 0.047	0.002	− 0.08	− 0.029	0.012	− 0.015	0.027	0.006	1

Variables definitions are provided in Table 2. The statistics in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

Table 5 Ordered Probit regression results of the credit rating and working capital relationship

$$RATING_{i,t} = a_{i,t} + \beta_1 NWC_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 LEV_{i,t} + \beta_4 COVERAGE_{i,t} + \beta_5 LOSS_{i,t} + \beta_6 CAP\_INTEN_{i,t} + \beta_7 SUBORD_{i,t} + \beta_8 BIG4_{i,t} + \varepsilon_{i,t}$$

Dependent variable	Rating		MICRORATING		Rating		MICRORATING	
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
NWC	0.324***	0.316***	0.345***	0.326***				
	(0.029)	(0.032)	(0.028)	(0.029)				
CCC					0.0010***	0.001***	0.0011***	0.0009***
					(0.0001)	(0.001)	(0.0001)	(0.0001)
SIZE	0.301***	0.489***	0.286***	0.480***	0.304***	0.490***	0.290***	0.481***
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
COVERAGE	0.021***	0.052***	0.023***	0.053***	0.021***	0.0519***	0.023***	0.053***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.0009)	(0.001)	(0.001)
LEV	− 1.990***	− 1.624***	− 1.845***	− 1.483***	− 1.972***	− 1.617***	− 1.828***	− 1.478***
	(0.033)	(0.035)	(0.031)	(0.032)	(0.033)	(0.034)	(0.031)	(0.032)
CAP_INTEN	0.550***	0.423***	0.523***	0.420***	0.587***	0.437***	0.560***	0.434***
	(0.012)	(0.015)	(0.012)	(0.014)	(0.012)	(0.015)	(0.012)	(0.014)
LOSS	− 0.797***	− 0.655***	− 0.794***	− 0.665***	− 0.796***	− 0.658***	− 0.794***	− 0.668***
	(0.014)	(0.014)	(0.013)	(0.013)	(0.014)	(0.0145)	(0.013)	(0.013)
BIG4	0.064***	− 0.001	0.079***	0.012	0.068***	0.0004	0.082***	0.014
	(0.012)	(0.012)	(0.011)	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)
SUBORD	− 0.102*	− 0.164***	− 0.135**	− 0.205***	− 0.199***	− 0.160***	− 0.132**	− 0.202***
	(0.062)	(0.064)	(0.058)	(0.059)	(0.062)	(0.063)	(0.058)	(0.059)
Year effect		Yes		Yes		Yes		Yes
Industry effect		Yes		Yes		Yes		Yes
Pseudo R^2	0.1932	0.2874	0.1220	0.1879	0.1946	0.288	0.123	0.1883
Firm-year Observations	43,183	43,183	43,183	43,183	43,183	43,183	43,183	43,183

Variables definitions are provided in Table 2. Note: standard errors are reported in parentheses. ***, **, and * indicate two-tailed significance at the 1%, 5%, and 10% levels. The results in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

Table 4 shows the correlation matrix between the variables of interest; the table shows that the correlation is not very high, the maximum value between LOSS and COVERAGE is 33.3%. Therefore, we can conclude that the multicollinearity problem is not a serious concern.

Empirical results

This section focuses on our regression on the effect of the operating working capital policy on a company's credit rating. We examine the main hypothesis of this study, namely, that a conservative working capital policy is associated with a high credit rating. A number of different estimates are calculated using our proposed model. This enables more robust results by controlling for firm and industry effects.

Table 5 presents the credit rating regression; the dependent variable is the firm credit rating class of Standard & Poor's domestic long-term issuer rating (RATING). The variable of interest is NWC. Columns 1 and 2 show the regression results for an ordered probit for NWC and the control variables. In column 2, we add year and industry effects, while in columns 3 and 4, we use MICRORATING as a proxy for credit rating. The relationship between NWC and credit rating is positive and statistically significant in all models in the columns; a *P* value of < 0.01 is found in both ordered probit regressions. These results do not change when we include the year and industry effects, as shown in column 2. Thus, the results support the hypothesis that investment in working capital (conservative working capital policy) enhances the probability of a firm having a good credit rating. In columns 5, 6, 7, and 8, we use the CCC as a proxy for the dependent variable; the results are also qualitatively similar. Our results support the findings of Blinder and Maccini (1991), Corsten and Gruen (2004), and Baños-Caballero et al. (2012), who find that a firm's risk increases with an aggressive working capital policy because of the loss of sales due to possible stock-outs, which reduces market share and creates interruptions in the production process, or a loss of customers due to an aggressive accounts receivable strategy. The signs of the control variables are consistent with those in prior research. We find a positive and statistically significant relationship between credit rating and size (SIZE), due to the lower asymmetric information of larger firms; interest coverage ratio (COVERAGE), which indicates that firms with a higher ability to pay their debt interest are less likely to default; capital intensity (CAP_INTEN), which indicates that firms with a higher capital intensity present lower risk since these firms can use their fixed assets as collateral; and the BIG4 coefficient, showing that firms that reduce managerial opportunistic behavior have a better credit rating. However, credit rating has a negative relationship with leverage (LEV), losses (LOSS), and subordinate debt (SUBORD), implying that firms with a high leverage ratio, unprofitable firms, and firms with subordinated debt have a higher probability of receiving a lower credit score.

As a robustness check, we control for the firm-specific effect by using a random-effect ordered probit regression; the results are qualitatively similar (for brevity, the results are not included).

The concave relationship between NWC and credit rating

This section examines whether high levels of working capital decrease the credit rating. As postulated by Soenen (1993) and Baños-Caballero et al. (2012), high investment in working capital might lead firms to bankruptcy since a high level of inventory incurs costs such as rent, insurance, and security. A high level of accounts receivable is associated with a high probability of a customer default. Specifically, we expect a U-shaped relationship between a firm's credit rating and investment in working capital. Thus, we examine the nonlinear relationship by including the square of NWC into Eq. (1). Table 6 presents the results. The results postulate that the coefficient of NWC is positive and its square (NWC^2) is negative and statistically significant (*P* value < 0.01), and both coefficients are statistically significant. This confirms that an overly conservative working capital policy (high investment in working capital) increases the probability of bankruptcy, which adversely affects a firm's credit rating. Thus, our results show that when working capital is below the optimal level, the benefits from low production disruption and stimulating sales enhance the credit rating of firms. On the other hand, high investment in working capital might suggest a high risk of uncollectibility and impose high financing costs for these receivables; furthermore, high inventory investment is subject to the risk of obsolescence, spoilage, and greater financing and holding costs.

Table 6 Ordered Probit regression results of the non-linear relationship between credit rating and working capital

$$RATING_{i,t} = a_{i,t} + \beta_1 NWC_{i,t} + \beta_2 NWC_{i,t}^2 + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 COVERAGE_{i,t} + \beta_6 LOSS_{i,t} + \beta_7 CAP\_INTEN_{i,t} + \beta_8 SUBORD_{i,t} + \beta_9 BIG4_{i,t} + \varepsilon_{i,t}$$

Dependent variable	**Rating**
	Column 1
NWC	0.302***
	(0.032)
NWC^2	− 0.032***
	(0.012)
SIZE	0.489***
	(0.004)
COVERAGE	0.052***
	(0.001)
LEV	− 1.626***
	(0.035)
CAP_INTEN	0.419***
	(0.015)
LOSS	− 0.654***
	(0.014)
BIG4	− 0.002
	(0.012)
SUBORD	− 0.165***
	(0.064)
Year effect	Yes
Industry effect	Yes
Pseudo R^2	0.2875
Firm-year observations	43,180

Variables definitions are provided in Table 2. Standard errors are reported in parentheses. ***, **, and * indicate two-tailed significance at the 1%, 5%, and 10% levels

The results in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

Components of working capital and credit rating

In the previous section, an NWC proxy is used to examine the relationship between the operating working capital policy and credit rating. Therefore, the positive relationship between NWC and credit rating is due to the management policy of the NWC components. A useful exercise is to examine the relationship between each component of working capital and credit rating. Thus, in Table 7, we examine the relationship between (AR), (INV), and (AP) and rating. Consistent with our prediction, the results in Table 7 show a positive and significant relationship between credit rating and (INV) and (AR), showing that higher levels of investment in inventory and accounts receivable will increase the probability of a firm receiving a higher credit score. However, the negative and significant impact of (AP) on credit rating indicates that increasing the level of accounts payable on a firm's balance sheet will increase the likelihood of this firm receiving a lower credit rating. Furthermore, we examine the U-shaped relationship between the components of working capital and credit rating. The coefficients of AR^2 and INV^2

Table 7 Ordered Probit regression results of the relationship between working capital components (accounts receivable, inventory, and accounts payable) and credit rating

Dependent variable	**Rating**	
	Column 1	**Column 2**
AR	0.0016***	0.0025***
	(0.0001)	(0.0002)
AR^2		− 0.0000023***
		(0.0000005)
INV	0.0004***	0.0014***
	(0.0001)	(0.0002)
INV^2		− 0.0000024***
		(0.0000003)
AP	− 0.0011***	− 0.0011***
	(0.0001)	(0.0002)
AP^2		0.000000033
		(0.0000003)
SIZE	0.4906***	0.4912***
	(0.0044)	(0.0044)
COVERAGE	0.0523***	0.0521***
	(0.0009)	(0.0009)
LEV	− 1.6270***	− 1.6152***
	(0.0349)	(0.0350)
CAP_INTEN	0.4443***	0.4564***
	(0.0153)	(0.0154)
LOSS	− 0.6586***	− 0.6588***
	(0.0145)	(0.0145)
BIG4	0.0016	0.0042
	(0.0120)	(0.0120)
SUBORD	− 0.1650**	− 0.1590**
	(0.0639)	(0.0639)
Year effect	Yes	Yes
Industry effect	Yes	Yes
Pseudo R^2	0.2888	0.2893
Firm-year observations	43,141	43,141

Variable definitions are provided in the Table 2. Standard errors are reported in parentheses. ***, **, and * indicate two-tailed significance at the 1%, 5%, and 10% levels. The results in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

are negative and significant. In addition, AP^2 is negative but not significant. These results indicate that when AR and INV are below the target level, the influence on credit rating is positive. Conversely, above-optimal investment in the components of working capital has a negative relationship with credit rating.

Deviation from the optimal working capital level and credit rating

The U-shaped relationship between working capital level and credit rating is confirmed in Table 8, due to the quadratic relationship between NWC and credit rating. In this section, we extend our regression and attempt to determine whether deviation from the optimal working capital inversely affects the credit rating; the cost of holding an amount of working capital lower than the target (such as stock sold out and losing on credit

Table 8 Ordered Probit regression results of the relationship between credit rating and deviation from optimal working capital

$$RATING_{i,t} = a_0 + \delta_1 DEV_{i,t} + \delta_2 DEV_{i,t} * above + \delta_3 SIZE_{i,t} + \delta_4 LEV_{i,t} + \delta_5 COVERAGE_{i,t} + \delta_6 LOSS_{i,t} + \delta_7 CAP_{INTEN\ i,t} + \delta_8 SUBORD_{i,t} + \delta_9 BIG4_{i,t} + \varepsilon_{i,t}$$

Dependent variable	Rating	
	Column 1	Column 2
DEV	− 0.009***	− 0.010***
	(0.001)	(0.001)
DEV*ABOVE		0.0020***
		(0.0002)
SIZE	0.503***	0.507***
	(0.005)	(0.005)
COVERAGE	0.056***	0.056***
	(0.001)	(0.001)
LEV	− 1.528***	− 1.520***
	(0.038)	(0.038)
CAP_INTEN	0.318***	0.339***
	(0.017)	(0.172)
LOSS	− 0.638***	− 0.635***
	(0.016)	(0.016)
BIG4	− 0.017	− 0.017
	(0.013)	(0.013)
SUBORD	− 0.136*	− 0.131*
	(0.072)	(0.072)
Year effect	Yes	Yes
Industry effect	Yes	Yes
Pseudo R^2	0.2883	0.2892
Firm-year observations	37,923	37,923
Likelihood-ratio test		(0.000)

Variable definitions are provided in Table 2. Standard errors are reported in parentheses. ***, **, and * indicate two-tailed significance at the 1%, 5%, and 10% levels. The results in this table are based on annual panel data of U.S. listed firms from WRDS merged with CRSP/Compustat files for the period between 1985 and 2017

sales) may send a signal of the firm's riskiness. In addition, a firm's bankruptcy cost may increase as the firm increases its investment in working capital. In the first step, we examine the relationship between deviation from the optimal working capital and credit rating. In the next stage, we examine whether the deviation on the upper and lower sides of the optimal NWC adversely affects the firm's credit rating; the deviation from NWC is interacted with a dummy variable that is equal to one if the deviation is above the optimal deviation. Thus, in the second stage, we examine whether these deviations (i.e., negative or positive) from the target working capital adversely affect the credit rating. We estimate the optimal working capital using the following equation:

Equation (2)—optimal NWC

$$\mathrm{NWC}*_{i,t} = \alpha_0 + \delta_1 \mathrm{CASH}_{i,t} + \delta_2 \mathrm{LEV}_{i,t} + \delta_3 \mathrm{GROWTH}_{i,t} + \delta_4 \mathrm{TANG}_{i,t} + \delta_5 \mathrm{LEV}_{i,t} + \delta_6 \mathrm{PROF}_{i,t} + \delta_7 \mathrm{SIZE}_{i,t} + \varepsilon_{i,t} \tag{2}$$

Equation (3)—deviation from optimal target

$$RATING_{i,t} = a_{i,t} + \delta_1 DEV_{i,t} + \delta_2 SIZE_{i,t} + \delta_3 LEV_{i,t} + \delta_4 COVERAGE_{i,t} + \delta_5 LOSS_{i,t} + \delta_6 CAP\_INTEN_{i,t} + \delta_7 SUBORD_{i,t} + \delta_8 BIG4_{i,t} + IndustryEffects_{i,t} + YearEffects_t + \varepsilon_{i,t} \quad (3)$$

To calculate the optimal NWC, we follow the model of Baños-Caballero et al. (2014), where $CASH_{it}$ is cash flow, and is calculated by the ratio of depreciation plus net income to total assets; LEV_{it} is the firm's leverage, and is calculated by total debt to total assets; $GROWTH_{it}$ is measured by the percentage change in total revenue; $TANG_{it}$ is the firm's investment in fixed assets, and is calculated by the ratio of net fixed assets to total assets; $PROF_{it}$ is the firm's profitability, and is measured by earnings before interest and taxes to total assets; and $SIZE_{it}$ is the firm's size, and is calculated by the natural logarithm of total assets.

We use the residual from Eq. (2) and replace the NWC variable with it. The next step is to use the regression residual as a proxy for deviation from the optimal working capital (Tong 2008). The residual value can be positive or negative. Therefore, we use the absolute value as a proxy for deviation. We use Eq. (1) and replace NWC with the absolute value of the residual deviation. We expect the credit rating to be adversely affected as the NWC of the firm deviates from the optimal NWC level; thus, our expectation is $\delta_1 < 0$ in Eq. (3).

The results in Table 8 from estimating Eq. (3) are based on replacing the variables NWC and NWC^2 in Eq. (1) with the absolute residual from Eq. (2). Consistent with our expectations, the findings in Table 8 show that the coefficient of DEV is negative and statistically significant. This confirms that there is a point at which working capital has a positive relationship with credit rating, and moving from this point adversely affects this relationship. Since the results from Eq. (3) do not indicate whether deviations on both sides have an adverse effect on credit rating, we include in Eq. (4) a new variable (interaction term), which takes the value of one if the deviation is positive and zero if the deviation is negative. In Eq. (4), our main interest is to measure how the coefficients of DEV(δ_1) and DEV + DEV^{*above}($\delta_1 + \delta_2$) affect credit rating. Thus, we expect $\delta_1 < 0$ and $\delta_1 + \delta_2 < 0$; this enables us to examine the negative effect of both positive and negative deviation from the optimal working capital on credit rating.

$$RATING_{i,t} = a_0 + \delta_1 DEV_{i,t} + \delta_2 DEV_{i,t} * above + \delta_3 SIZE_{i,t} + \delta_4 LEV_{i,t} + \delta_5 COVERAGE_{i,t} + \delta_6 LOSS_{i,t} + \delta_7 CAP\_INTEN_{i,t} + \delta_8 SUBORD_{i,t} + \delta_9 BIG4_{i,t} + IndustryEffects_{i,t} + YearEffects_t + \varepsilon_{i,t} \quad (4)$$

The interaction term DEV^{*above} is defined as a dummy variable that takes the value of one for a positive residual and zero for a negative residual from the estimation in Eq. (2), in which ($\delta_1 + \delta_2$) represents the influence of an above-optimal working capital investment level on credit rating. If the deviation from the optimal working capital negatively affects the firm's credit rating, we expect the value of δ_1˂0, and ($\delta_1 + \delta_2$)˂0 if the deviation both above and below optimal working capital have an adverse impact on the firm's credit rating.

Column 2 of Table 8 shows the results from the interaction term; the results show that the deviation coefficient (DEV) is negative and statistically significant at a conventional level, and the interaction term DEV^{*above} is also statistically significant at the 1% level and positively related to credit rating. As mentioned by Tong (2008), the interaction term DEV^{*above} may have a positive value because the positive and negative residuals may offset each other. However, the main concern here is that the sum of $(\delta_1 + \delta_2)$ would be lower than zero, and the results, as predicted, are lower than zero; in column 2, $(\delta_1 + \delta_2)$ is $(-0.01 + 0.002) = -0.008$. We also conduct a likelihood-ratio test on the null hypothesis that the sum of the estimates of DEV and DEV^{*above} is zero. The test rejects the null hypothesis at a conventional level, which supports that the deviation on both sides of the optimal working capital has a negative effect on credit rating. A likelihood-ratio test ratio for the joint significance levels of $(\delta_1 + \delta_2)$ is lower than zero and statistically significant at the 1% level.

Finally, credit rating may have an impact on a firm's ability to buy goods on credit and finance their accounts receivable using low-cost external financing. Thus, using the same approach as Attig et al. (2013) and Bendig et al. (2017), we test for any potential endogeneity bias caused by reverse causality. Thus, we repeat the regression model in Table 5 using the lagged values of NWC and CCC. The results are qualitatively similar, in which the coefficients of the lagged value of NWC and CCC are positive and statistically significant at a conventional level (the results are available from the authors upon request), which suggests that the endogeneity problem may have no impact on our results.

Concluding remarks

WCM is considered to be one of the most important factors in a firm's success or failure. Therefore, in this study, we investigate whether a firm's WCM can affect the perceived riskiness of external evaluators, such as the credit-rating agency S&P. The rationale for this relationship is that inappropriate WCM may increase a firm's riskiness through under- or over-investment in working capital components. Based on U.S. panel data of 43,141 firm-year observations from 1985 to 2017, we find evidence of a relationship between WCM and credit rating. In particular, we find that this relationship is concave, in which firms have an optimal working capital level that balances costs and benefits to reduce firms' riskiness; hence, credit is improved. Further, we find that the concave relationship is applicable to working capital components (inventory, accounts receivable, and accounts payable) and that deviation from the optimal working capital level may decrease a firm's credit rating score.

This study aims to fill the gap in the existing literature by offering for the first time direct evidence of a relationship between WCM and credit rating. Based on theory and our empirical evidence, this study will help policy makers, managers, decision makers, and credit-rating agencies recognize that WCM can affect a firm's riskiness, which in turn is reflected in its credit rating. This study highlights the advantages and disadvantages of over- and under-investment in working capital and its relationship with credit rating. However, a limitation of this study that should be taken into consideration is that we were unable to test the exact cost of over- and under-investment in working capital, which could have helped us understand the relationship more accurately.

Author contributions

AA analysed and interpret the results. AS made the theoretical framework. HQ drafted the work. All authors read and approved the final manuscript.

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Availability of data and materials
The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are available at https://wrds-www.wharton.upenn.edu/

Declarations

Competing interests
The authors declare no competing interests.

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