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KEYWORDS	ABSTRACT
Working capital management; Financial distress; Cash conversion cycle; Corporate life cycle; Trade credit; Emerging markets; Liquidity risk	The study explores the potential of non-linearity between working-capital policy and corporate financial health and investigates if it changes throughout the corporate life cycle stages and in different institutional environments. This study uses a sample of 25,258 listed non-financial, non-utility firms in 134 economies with 347,736 firm-year observations to investigate the association between the cash conversion cycle (CCC) and Altman's international Z"-score and an accounting-based distress-zone indicator, from 2000 to 2025. The quadratic specifications yield all positive terms for the CCC, and all the squared terms are negative, with fitted vertices for the baseline model being 355.29 days, 355.42 days for the sector and year fixed effects model and 376.53 days for the firm fixed effects version. The distress models show the convex relationship in which risk minimising fitted turning points are found in the range of 259.60 days to 306.25 days. The proximity of, or departure from, a number of the vertices to the 365-day support is treated as indicative of the model-based boundary and is not considered as universal operating targets. The attitude towards the length of the operating cycle differs from life-cycle and development groups: mature and advanced economy companies are more tolerant of the lengthening of their operating cycle whereas declining and emerging market companies are less tolerant of operating cycle lengthening. The inventory interpretation also shows separate inventory, receivables and payables. Lagged and dynamic specifications preserve the basic curvature, whereas peer-IV and system-GMM estimates can have positive CCC association, but not necessarily be able to replicate the quadratic turning point. Overall, the evidence indicates fragility of working capital is related to the state of the organization, and liquidity policy should be interpreted alongside the composition of the operating cycle and financing conditions.
ARTICLE HISTORY	
Date of Submission: 18-08-2026	
Date of Acceptance: 21-09-2026	
Date of Publication: 26-09-2026	
	 2026 Journal of Social Research Development
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Email:	Ahmad.ghazali@uog.edu.pk
DOI	https://doi.org/10.59075/jsrd.v7i7.563
Volume/Issue	7(7), 2026, 432-456

Introduction

Working capital management is the tie up between short term operational policy and liquidity, financing capability and risk of the company. The cash conversion cycle (CCC) is a period of time from the cash outlay on the inputs through the cash coming from the customers but cash consequences are not necessarily monotonic. A faster cycle can free up cash and increase efficiency, but excessive compression can decrease inventory buffers, also limit credit for customers, and redirect liquidity pressure up the supply chain. On the other hand, a long cycle can be conducive to operational continuity and commercial relationships, but too much inventory and slow collections tie up resources and may undermine debt service capability. In recent times, there have been more studies that focus on working capital as a risk-return decision instead of merely an efficiency measure (Tarkom, 2022; Habib, 2022; Kiyamaz et al., 2024; Zhang & Yu, 2025).

This tension is increasing in importance in the post-Covid era and the multi-faceted disruptions to supply chains. When faced with uncertainty, companies will react by changing the levels of their inventories, receivables and payables and the conditions of external financing will affect the cost. COVID-19 virus also had an impact on working-capital decisions; firms that were in a more positive position with respect to working-capital had more exposure risks in their supply chains, as a result of increased inventories and increased receivables (Tarkom, 2022; From chain to capital, 2025). The banking uncertainty, financial constraints, information asymmetry and production-network conditions reported to influence trade credit in previous studies (Gyimah et al., 2020; Jory et al., 2020; Gofman & Wu, 2022; Ersahin et al., 2024). The results showed that the cost of a given CCC would be correlated with the ability of the internal financial organization of the CCC and the external financial climate in which the CCC operated.

The question is answered for a global sample of 25,258 publicly listed non-financial, non-utility companies for the period 2000-2025, and for 134 economies, over 347,736 firm-year observations. The result is Altman's international Z"-score, along with a distress-zone indicator, and a purged solvency measure which doesn't count NWC in the score. The empirical design features quadratic CCC specifications, discrete distress models, corporate life-cycle partitions, following Dickinson's classification of cash-flows, advanced economy versus emerging economy comparisons, and endogeneity-oriented sensitivity analyses.

Our setting has three merits. Firstly, recent studies reported considerable variation in working-capital behavior across countries, and that working-capital behavior affects performance, in particular between developing and developed countries (Kiyamaz et al., 2024). Secondly, the study about corporate life cycles showed that the cost of borrowing, credit quality, investment opportunity and risks will differ between the introduction, growth and decline and maturity stages (Abuhommous, 2023; Amin et al., 2023). Third, the literature on SCF emphasizes that receivables and payables are not merely accounting balances, but also "liquidity, information and distress channels of production network" (Gofman & Wu, 2022; Ersahin et al., 2024; Tang et al., 2025). The strands drive a collective approach that leads to a shared set of goals, with multiple interpretations of the same nominal CCC coming to life in different institutional and firm contexts.

We find that positive linear coefficient of CCC and negative squared coefficient of CCC in all the specifications make the base models concave in CCC. Vertices that are fitted are 335.42 days and 376.53 days. The distress models result in the reciprocal, and points minimizing the risk are fitted between 259.60 days and 306.25 days. Importantly, these estimates are not saying that the firms should aim for such long cycles. There are several turning points in the vicinity of and beyond the range of support and hence it is reasonable to assume that overall solvency increases in much of the range observed and decreases in the upper tail in the neighborhood of these turning points. This is an interpretation based on what it means to avoid a fitted quadratic feature as a prescription for the treasury rule.

We also record meaningful economic differences. Like for older firms and firms located in advanced economies, the solvency curves are more right-shifted, suggesting that firms had more ability to accommodate lengthening of the operating cycle. The average of firms in declining companies and firms in emerging and developing economies is smaller and has a more limited range of estimated tolerances. Within the economically relevant range of days, inventory and receivable days are non-linear at the component level and the longer the payable days, the lower the solvency and the greater the distress. This is a paid result and in this case, it implies either that the supplier financing can be beneficial or that the payment is slower than usual, indicating that the supplier is experiencing liquidity difficulties or has reduced bargaining power (According to Routledge, 2023; Davis et al., 2025; Tang et al., 2025).

There are four ways in which this research is a contribution to the literature: First, it focuses the working-capital conversation not just on profitability, but on balance-sheet resiliency and distress risk. Secondly, it addresses the mechanical overlaps between working capital and the Altman framework of a 'purge' solvency score. Third, it reflects two aspects of the heterogeneity of corporate life cycle, as well as institutional development within a non-linear framework. Fourth, it separates inventories and receivables and payables so as to differentiate inventory buffers from trade-credit buffers. The remainder of the paper is laid out as follows. The literature and hypotheses come to be formulated in Section 2. The sample and an empirical design is described in Section 3. The results and robustness analysis are presented in section 4. Section 5 concludes.

Literature review and hypothesis development

Working capital, liquidity, and financial fragility

Working capital supports production and customer credit but also ties up funds in inventory and receivables. A short cash conversion cycle (CCC) releases cash, although excessive reductions may weaken operating buffers; a long cycle increases financing needs. Evidence shows that these choices respond to external conditions. Jory et al. (2020) link economic policy uncertainty to tighter trade credit and show that excessive tightening can erode firm value. Tarkom (2022) associates pandemic exposure with longer CCC. Together, these studies motivate a trade-off between operating continuity and the financing cost of working capital.

Financial-distress research reinforces the importance of cash-flow risk and financing flexibility. Li et al. (2023) associate higher cash-flow risk with greater distress likelihood, while Wu et al. (2024) show that the relationship between financial flexibility and distress depends on economic and policy conditions. Habib and Kayani (2022) find that working-capital efficiency is associated with lower distress likelihood among Emirati firms. These findings motivate, rather than establish, the proposed nonlinear relationship: moderate working-capital investment may support solvency, whereas insufficient buffers or excessive cash commitments may increase fragility.

H1A. The relationship between CCC and financial solvency is concave.

H1B. The relationship between CCC and financial distress risk is convex.

Corporate life-cycle heterogeneity

Corporate life-cycle stages differ in operating needs, internal cash generation, and access to finance. Introduction and growth firms often finance expansion before collecting sales revenue, whereas mature firms typically have more established operations and financing relationships. Declining firms may face weaker demand and refinancing pressure. Abuhommous (2023) links life-cycle stage to credit ratings, and Amin et al. (2023) find higher borrowing spreads for introduction and decline firms than for mature firms. This evidence supports treating life-cycle stage as a source of financing heterogeneity.

For introduction and growth firms, inventory and receivables can absorb funds needed for investment and commercialization. A longer CCC may therefore reflect expansion while creating a financing gap when internal cash generation is insufficient. For mature firms, more stable cash flows and established lender and supplier relationships may help absorb temporary operating-cycle mismatches.

In decline, longer inventory or receivable periods may instead indicate weakening demand or deteriorating collections. The same CCC can therefore have different financial implications across stages. These mechanisms motivate stage-specific curves and turning points rather than a common relationship for all firms.

Evidence from related corporate decisions also supports life-cycle heterogeneity. Ashraf et, al (2025) find that restructuring charges vary across life-cycle stages and that institutional ownership moderates this relationship. Ghazali et, al (2026) find a positive association between R&D expenditure and carbon emissions among BRICS firms, with a weaker association in growth and maturity stages. These studies examine different outcomes, but support considering life-cycle differences in operating conditions and resource allocation when developing stage-specific working-capital hypotheses.

H2. The CCC-solvency relationship varies across life-cycle stages, with mature firms tolerating longer cycles than declining firms.

Institutional development and financing capacity

Institutional development influences whether operating-cycle gaps translate into financing pressure. Bank credit, capital markets, and receivables financing can help firms fund cash tied up in inventory and customer credit. Where these channels are less accessible, firms may rely more on internal liquidity and supplier finance. Kiyamaz et al. (2024) find that working-capital components have different associations with performance in developed and emerging economies, supporting the need to examine institutional differences.

Broader financing options may allow firms in advanced economies to sustain longer operating cycles before experiencing liquidity pressure. Firms in emerging markets and developing economies may face tighter financing constraints, while supplier credit depends on suppliers' own financial capacity. Accordingly, comparable CCC values need not imply comparable financial resilience across economies.

H3. The CCC–solvency curve is flatter and more right-shifted in advanced economies than in emerging markets and developing economies.

Joint moderation and component asymmetry

Life-cycle stage and institutional development may jointly shape working-capital resilience because internal cash generation and external financing capacity are complementary. A mature firm in an advanced economy may absorb operating-cycle delays through both channels. A declining firm in an emerging market or developing economy may face constraints in both. This interaction motivates comparing CCC curves and turning points across life-cycle and economic-development groups.

Related resource-allocation evidence also highlights conditional effects. Ghazali et al (2026) report a negative baseline association between natural-resource assets and R&D, with variation by firm age, profitability, and governance; the association becomes positive under high restructuring intensity. Although their outcome is innovation rather than working-capital solvency, their findings reinforce the relevance of organizational conditions when interpreting the financial implications of corporate resources.

H4. Life-cycle stage and economic development jointly moderate the shape and turning point of the CCC–solvency relationship.

The aggregate CCC also combines components with different economic meanings. Days sales of inventory (DSI) reflect inventory holding time and may represent operating buffers or unsold stock. Days sales outstanding (DSO) reflect collection time and may indicate customer-credit provision or delayed payment. Days payable outstanding (DPO) reflect supplier-payment time. Although higher DPO mechanically reduces CCC, it may represent negotiated supplier financing or

difficulty meeting payment obligations. Component-level analysis is therefore necessary to distinguish operational support from financial strain.

Trade-credit evidence further supports this distinction. Gofman and Wu (2022) relate trade-credit patterns to firms' positions and profitability within production networks. Ersahin et al. (2024) show that trade credit can support relationships during operating shocks, but financial constraints limit suppliers' ability to provide it. These mechanisms motivate separate nonlinear relationships for inventory, receivables, and payables.

H5. Inventory and receivable days have concave associations with solvency and convex associations with distress risk; longer payable periods are associated with lower solvency and higher distress risk over the central range.

Data

Sample construction

Empirical sample comprised the data of the publicly listed companies from S&P Capital IQ with regard to the balance sheet, income statement, cash-flow and operating cycles for the fiscal years 2000 to 2025. Financial institutions and regulated utilities are not included because their capital requirements and liabilities are not directly comparable to those of industrial firms, and their process of working-capital is not comparable. Also, we reject observations in which total assets (or liabilities) is negative, and we request that valid information be provided for current assets, current liabilities and cash flow. To ensure that the operating-cycle is not unrealistic, it is limited in the range of $[-100, 365]$ days, and its components are limited in the range of $[0, 365]$ days in CCC. The final unbalanced panel consists of 347,736 firm-year observations of 25,258 firms from 134 economies.

Life-cycle stages are determined based on the sign patterns of the operating, investing and financing cash flows based on Dickinson (2011). The Advanced Economies (AE) classification and the Emerging Market and Developing Economies (EMDE) classification are based on the definition of Advanced economies (AE) and Emerging Market and Developing Economies (EMDE) used in the International Monetary Fund (IMF) World Economic Outlook (WEO). All continuous variables are Winsored at 1st and 99th percentiles.

Dependent and explanatory variables

Altman's four variable international Z'' -score is the main measure of financial health. Firms are classified as Safe ($Z'' > 2.60$), Grey ($1.10 \leq Z'' \leq 2.60$), or Distress ($Z'' < 1.10$). The Distress Dummy is a binary variable which equals one when Z'' is less than 1.10 and zero otherwise, and differs from actual bankruptcy events since it is based on accounting data. The mechanical overlap of the CCC construct is reduced by including also a purged solvency measure (Z_{adj}) to exclude the net-working-capital component of the construction.

The most important independent variable is the cash conversion cycle (CCC) which is calculated as days sales of inventory + days sales outstanding – days payables outstanding. On top of this, component models of DSI, DSO and DPO are estimated. The controls are firm size, financial leverage, cash holdings, operating ROA and sales growth. Fixed effects at the firm, sector and year levels are added as appropriate, and SEs are clustered.

There are two scores, one continuous solvency score and one binary distress zone score, both of which are deliberate. The continuous Z'' measure registers changes in a firm's financial well-being prior to entering distress while the binary indicator only records if the firm's accounting configuration was in the traditional distress area. These results are in the direction of similar outcomes and for results in this direction, the representation of functional financial health is less dependent on the direction of the results. The purged score gives an extra diagnostic as conventional Altman construction has net working capital. If that component is subtracted, the concern that a link between CCC and Z' is only a mechanical one because they are balance-sheet inputs, not relevant economically, is removed.

Theoretical Framework and Empirical Modeling

The baseline model represents the relationship between Z'' and CCC, CCC^2 , controls, fixed effects. The coordinates of the vertex are $-\beta_1/2\beta_2$. A vertex near or beyond the range of data is seen as evidence of direction and curvature, but not as a literal optimum, we do not consider a vertex to have economic significance unless it is within the observed range of data. In the case of distress, we estimate linear-probability, probit, logit and firm-fixed-effects LPM. Heterogeneity is viewed through the prism of stage of life-cycle, development group and combined cells. The tests that are endogeneity oriented are: Lagged CCC, a peer-based instrumental-variable specification, a dynamic panel and system GMM.

The quadratic terms have to be interpreted with care. A positive linear term and a negative squared term doesn't necessarily indicate that the fitted equation is concave by itself, but it does mean that there are interior optimal solutions that may be economically relevant. If the number of observations near the implied vertex is small, then the implied vertex is not necessarily supported by the data and could be misleading if the vertex is outside the set of the admissible or observed values. Therefore care has been taken to report turning points but analyze in conjunction with the imposed CCC support, and the shape of the fitted curve. Frequently, the vertex near the upper boundary serves as a cue to managers that the marginal association between the two variables is positive, but diminishing as the CCC moves toward that boundary and not as a set rule for moving the operating cycle to the upper boundary.

Empirical Strategy

The endogeneity-oriented specifications are not intended to replace each other in the role of causal proofs. The question of simultaneity is taken care of in Lagged CCC: By comparing the financial health of the previous working capital condition with the subsequent financial health. Peer-based

instruments try to reflect the variation of working capital policy across the industry or peers, under the assumption that the exclusion-restriction is valid. Dynamic-panel and system-GMM methods can add persistence in financial health and part of the unobserved heterogeneity and simultaneity to the model, using internal instruments. The coefficient direction convergence is useful since each method assumes different things, but the quadratic term divergence is also of economic significance. The absence of a structural optimum in the IV or GMM model particularly should be used as a suspicion for the use of the baseline vertex as a structural optimum.

Empirical Results and Their Discussion

Descriptive statistics

Table 1 gives details of the composition of the sample. The advanced-economy observations make up 55.48% of the panel, while the EMDE observations make up 44.52% of the panel. The most mature group (44.36%) will be the largest group of mature firms. The overall accounting based distress rate is 20.41% and the highest distress rates are in the two stages of Introduction (28.45%) and Decline (28.91%). The patterns are consistent with the latest studies that found the relationship between the life-cycle stage and credit quality and loan interest rates (Abuhommous, 2023; Amin et al., 2023).

Table 1: Sample Composition by Economic Development, Corporate Life-Cycle Stage, Financial Solvency Zone, and Industry

Classification Dimension / Subgroup	Firm-Years (N)	Percent (%)	Distress Rate (%)	Mean Z"-Score
Panel A: Macroeconomic Development Group				
Advanced Economies (AE)	192,936	55.48	17.82	3.784
Emerging Markets & Developing Economies (EMDE)	154,800	44.52	23.64	3.182
Panel B: Corporate Life-Cycle Stage (Dickinson, 2011)				
Introduction (FLCS 1)	44,224	12.72	28.45	2.842
Growth (FLCS 2)	83,562	24.03	16.12	3.914
Mature (FLCS 3)	154,267	44.36	17.20	3.725
Shakeout (FLCS 4)	10,394	2.99	24.50	3.018
Decline (FLCS 5)	55,289	15.90	28.91	2.812
Panel C: Altman (1983, 2000) Financial Solvency Zones				
Safe Zone ($Z'' > 2.60$)	204,944	58.94	0.00	5.412
Grey Zone ($1.10 \leq Z'' \leq 2.60$)	71,832	20.66	0.00	1.854
Distress Zone ($Z'' < 1.10$)	70,960	20.41	100.00	-0.285
Panel D: Selected Global Industry Sectors				

Capital Goods & Manufacturing (GICS 20)	98,415	28.30	18.45	3.612
Information Technology (GICS 45)	52,840	15.20	17.10	4.125

The descriptive statistics are shown in Table 2. The average of the Z"-score is 3.516 and the distress rate is 20.4%. The mean of the CCC is 104.25 days, the median is 81.60 days and the range of the CCC imposed is wide. Average inventory, receivable and payable periods are 91.93 days, 74.43 days and 71.07 days respectively.

Table 2: Descriptive Statistics of the Study Variables

Variable	N	Mean	SD	P25	Median	P75	Min	Max
Altman Z"-Score	347,736	3.516	5.550	1.534	3.379	5.833	-24.328	19.467
Purged Z"-Score (Z _{adj})	347,736	2.216	4.756	1.064	2.159	3.778	-24.809	16.452
Distress Dummy (Z" < 1.10)	347,736	0.204	0.403	0.000	0.000	0.000	0.000	1.000
Cash Conversion Cycle (days)	347,736	104.249	110.041	32.300	81.600	150.800	-100.000	365.000
Days Sales of Inventory (days)	333,604	91.931	83.218	32.900	69.600	122.700	0.000	365.000
Days Sales Outstanding (days)	345,094	74.433	62.524	34.600	60.400	95.000	0.000	365.000
Days Payables Outstanding (days)	340,911	71.067	62.967	31.500	53.800	88.200	0.000	365.000
Firm Size (ln Total Assets)	347,736	12.173	2.077	10.799	12.107	13.487	7.091	17.452
Financial Leverage	347,736	0.232	0.202	0.060	0.201	0.352	0.000	1.001
Cash Holdings Ratio	347,736	0.129	0.132	0.033	0.087	0.179	0.001	0.648
Operating ROA (%)	347,736	2.918	8.202	0.820	3.330	6.440	-43.730	22.930
Sales Growth (%)	347,736	11.227	32.834	-4.180	6.740	20.990	-67.280	162.630

The moderate pairwise correlations are summarized in Table 3. Correlations of Z" with leverage and operating ROA are negative and positive, respectively, and the raw correlations of CCC with solvency and distress are small. The average value of VIF is 1.17, indicating that there is not likely to be conventional multicollinearity effects affecting the multivariate estimates.

Table 3: Correlation Analysis

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	VIF
(1) Altman Z"-Score	1.000									-
(2) Distress Dummy	-0.562*	1.000								-
(3) Cash Conv. Cycle	0.082*	-0.045*	1.000							1.14
(4) Firm Size (ln TA)	0.098*	-0.162*	0.012*	1.000						1.28
(5) Financial Leverage	-0.458*	0.312*	-0.094*	0.185*	1.000					1.22
(6) Cash Holdings	0.342*	-0.185*	-0.081*	-0.214*	-0.245*	1.000				1.18
(7) Operating ROA	0.412*	-0.298*	0.045*	0.082*	-0.212*	0.145*	1.000			1.16
(8) Sales Growth	0.054*	-0.065*	0.018*	-0.015*	-0.032*	0.048*	0.198*	1.000		1.08
(9) Dickinson FLCS	-0.085*	0.072*	-0.034*	0.042*	0.058*	-0.095*	-0.142*	-0.185*	1.000	1.12
Mean VIF										1.17

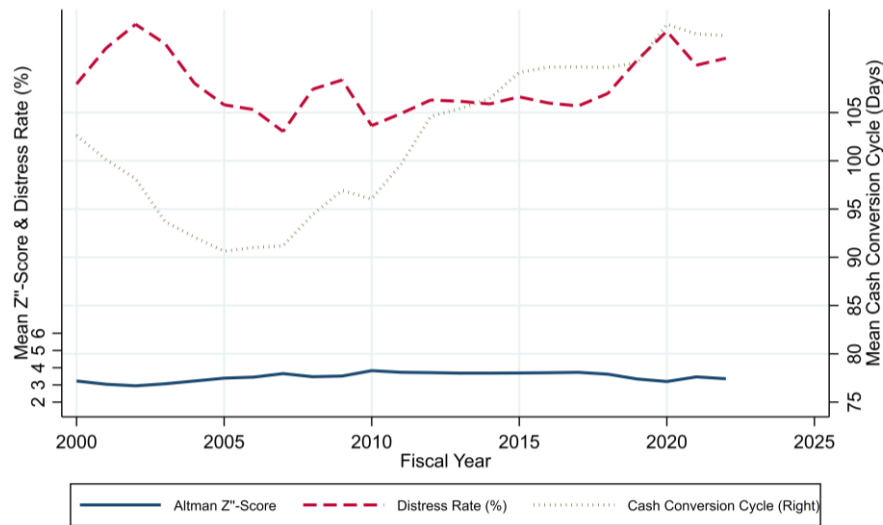


Figure 1: Global Longitudinal Trends in Financial Solvency, Distress Risk, and Working Capital Management

Baseline results

Table 4: Baseline Regression Results: Cash Conversion Cycle and Corporate Financial Solvency

Independent Variables	Model (1) Pooled OLS	Model (2) Year FE	Model (3) Quadratic OLS	Model (4) Sector & Year	Model (5) Firm Fixed Effects
Cash Conversion Cycle (CCC)	0.00412*** (0.00018)	0.00418*** (0.00018)	0.01771*** (0.00039)	0.01672*** (0.00039)	0.01476*** (0.00064)
CCC Squared (CCC^2)			-0.000025*** (0.000001)	-0.000025*** (0.000001)	-0.000020*** (0.000002)
Firm Size (ln Total Assets)	0.10412*** (0.00971)	0.10842*** (0.00972)	0.10850*** (0.00972)	0.08945*** (0.00978)	0.15505*** (0.01585)
Financial Leverage	-11.89541*** (0.10952)	-11.88421*** (0.10948)	-11.88293*** (0.10949)	-11.75412*** (0.10925)	-9.57030*** (0.18530)
Cash Holdings	4.61245*** (0.15951)	4.60124*** (0.15948)	4.59871*** (0.15948)	4.71254*** (0.15982)	4.79568*** (0.27440)
Operating ROA	0.31954*** (0.00325)	0.31885*** (0.00325)	0.31891*** (0.00325)	0.31542*** (0.00324)	0.26917*** (0.00632)
Sales Growth	-0.00921*** (0.00031)	-0.00924*** (0.00031)	-0.00923*** (0.00031)	-0.00918*** (0.00031)	-0.00998*** (0.00070)
Optimal CCC (Days)	-	-	355.29***	335.42***	376.53***
Industry Sector Fixed Effects	No	No	No	Yes	Absorbed
Year Fixed Effects	No	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	No	No	No	Yes
Observations (N)	347,736	347,736	347,736	347,682	347,736
Number of Clusters (Firms)	25,258	25,258	25,258	25,254	25,258
R-squared / Within R ²	0.5796	0.5798	0.5846	0.5864	0.3842
F-statistic	7830.63***	1702.95***	1686.68***	1288.28***	999.45***

Table 4 shows the solvency estimates at the baseline. The linear CCC metric is positive. Linear CCC metric is positive. In the pooled model, the sector-year fixed-effects model, and the firm fixed-effects model, CCC and CCC² are positive and negative, respectively. The fitted vertices are 355.29, 335.42, and 376.53 days, respectively. The signs of the coefficient of the terms are correct as in H1A, but it is important to make sure the position of the vertices is correct. The lower bound is close to the turning point of the firm fixed effects and the vertex is outside the range of the observed support. The economically defensible and correct reply is not that the marginal benefit is decreasing for a one-year CCC, but that it is decreasing in the upper tail of the observed distribution of CCCs.

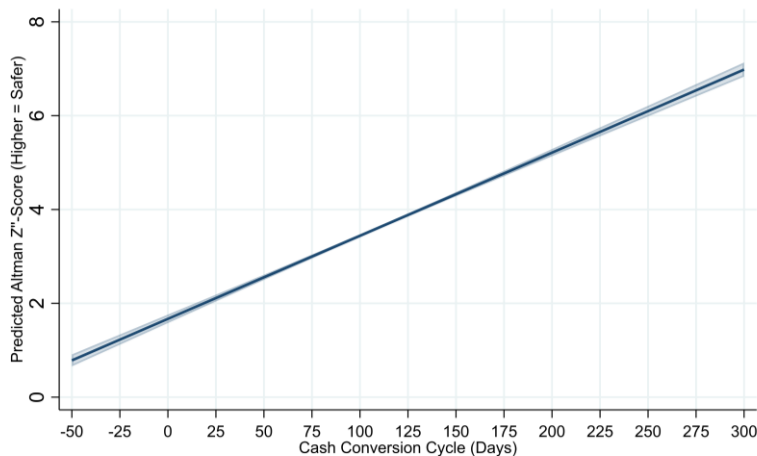


Figure 2: Fitted Corporate Financial Solvency Across the Cash Conversion Cycle

The complementary distress tests are given in table 5. In the quadratic LPM, probit, logit and firm-fixed-effects LPM models the squared term is negative and the linear term is positive. The risk minimisation might be between 259.60 and 306.25 days along the turning points. The results are consistent with H1B in terms of functional form, and they continue to substantiate the hypothesis that unbalanced working cycles, both short and long, can result in fragility, but not balanced ones.

Table 5: Cash Conversion Cycle and Financial Distress Risk

Independent Variables	Model (1) Linear LPM	Model (2) Quadratic LPM	Model (3) Clustered Probit	Model (4) Clustered Logit	Model (5) Firm FE LPM
Cash Conversion Cycle (CCC)	-0.00021*** (0.00002)	-0.00078*** (0.00003)	-0.00342*** (0.00015)	-0.00612*** (0.00026)	-0.00049*** (0.00005)
CCC Squared (CCC ²)		0.0000015*** (0.0000001)	0.0000063*** (0.0000003)	0.0000114*** (0.0000006)	0.0000008*** (0.0000001)
Firm Size (ln Total Assets)	-0.02145*** (0.00085)	-0.02142*** (0.00085)	-0.10542*** (0.00412)	-0.18954*** (0.00742)	-0.01245*** (0.00185)

Financial Leverage	0.74125*** (0.00842)	0.74120*** (0.00841)	2.85412*** (0.03845)	5.12458*** (0.07125)	0.51240*** (0.01542)
Cash Holdings	-0.11452*** (0.00941)	-0.11425*** (0.00940)	-0.54125*** (0.04512)	-0.98542*** (0.08125)	-0.08452*** (0.01845)
Operating ROA	-0.01712*** (0.00018)	-0.01710*** (0.00018)	-0.08452*** (0.00105)	-0.15421*** (0.00195)	-0.01124*** (0.00035)
Sales Growth	0.00012*** (0.00002)	0.00012*** (0.00002)	0.00054*** (0.00011)	0.00098*** (0.00021)	0.00008*** (0.00003)
Optimal CCC Minimizing Distress	-	259.60***	271.43***	268.42***	306.25***
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	No	No	No	Yes
Observations (N)	347,736	347,736	347,736	347,736	347,736
Number of Clusters (Firms)	25,258	25,258	25,258	25,258	25,258
R-squared / Pseudo R ²	0.3453	0.3542	0.2985	0.3012	0.1854
Model Test Statistic	F =	F =	Wald =	Wald =	F =
	1068.73***	993.89***	32845***	31950***	481.43***

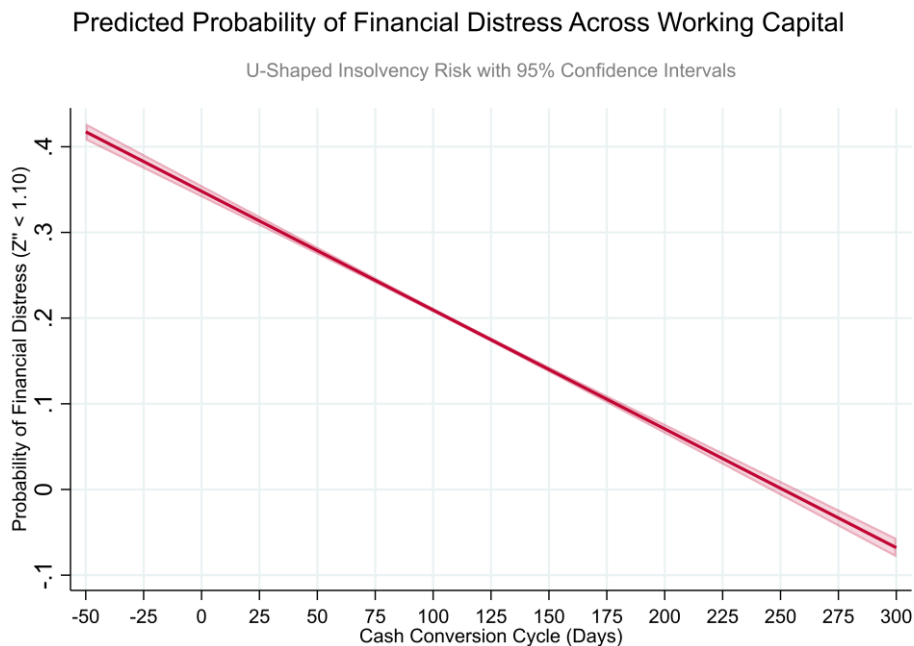


Figure 3: Linear-Probability Fitted Distress Risk Across the Cash Conversion Cycle

Life-cycle and institutional heterogeneity

Table 6 divides the sample into the segments corresponding to the different stages of the corporate life cycle. The curves of all three firms (Growth, Mature and Decline) share the same signs of CCC

and CCC², but differ in shape and position. The estimated extension of the cycle is larger for mature companies as compared to declining companies. It's consistent with the notion that the larger firms, with greater cash flow and financing history, can afford to hold inventories longer in the case of a slowdown in their cash-generating operations while the longer period of a decline is indicative of weak sales or collection.

Table 6

Independent Variables	Model (1) Growth (FLCS 2)	Model (2) Mature (FLCS 3)	Model (3) Decline (FLCS 5)
Cash Conversion Cycle (CCC)	0.01428** (0.00062)	0.01824** (0.00046)	0.01890** (0.00071)
CCC Squared (CCC ²)	-0.000021** (0.000002)	-0.000025** (0.000001)	-0.000028** (0.000002)
Firm Size (ln Total Assets)	0.05412** (0.01452)	0.06845** (0.01254)	0.18542** (0.02145)
Financial Leverage	-9.84512** (0.17845)	-12.12458** (0.14521)	-13.54125** (0.22145)
Cash Holdings	6.12458** (0.24512)	6.02451** (0.21458)	5.21458** (0.31245)
Operating ROA	0.24512** (0.00584)	0.19542** (0.00412)	0.32451** (0.00685)
Sales Growth	-0.00895**	-0.01045**	-0.00784**
Year Fixed Effects	Yes	Yes	Yes
Observations (N)	83,562	154,267	55,289
R-squared	0.5081	0.5448	0.6029
F-statistic	670.66**	858.80**	884.03**

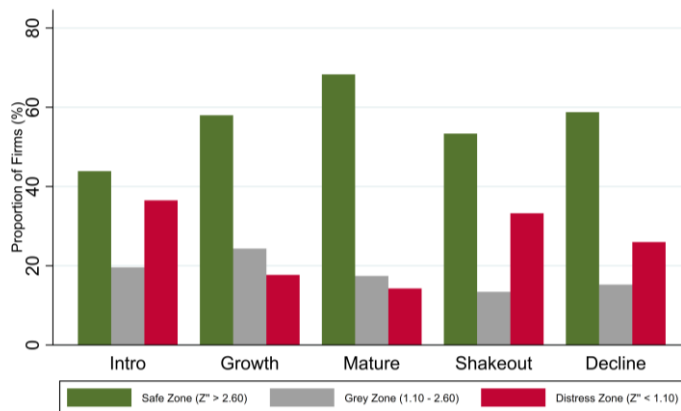


Figure 4: Distribution of Financial Solvency Zones Across Corporate Life-Cycle Stages

Tables 7 provides a comparison with the advanced economies. The populations are both concave with different degrees of concavity as suggested by the interaction terms. The profile of the advanced economies is also flatter, and more quite right, as is consistent with H3, and in line with recent evidence from the cross country literature, that the effects of working capital components may differ across financial systems (Kiyamaz et al., 2024).

Table 7 Cash Conversion Cycle and Financial Solvency: Advanced Economies versus Emerging Markets and Developing Economies

Independent Variables	Model (1) Advanced (AE)	Model (2) Emerging (EMDE)	Model (3) Pooled Interactive
Cash Conversion Cycle (CCC)	0.01754*** (0.00054)	0.01712*** (0.00045)	0.01712*** (0.00045)
CCC Squared (CCC^2)	-0.000022*** (0.000001)	-0.000028*** (0.000001)	-0.000028*** (0.000001)
CCC x AE Dummy			0.00042 (0.00070)
CCC^2 x AE Dummy			0.000006*** (0.000002)
Firm Size (ln Total Assets)	0.22451*** (0.01542)	-0.08451*** (0.01124)	0.09845*** (0.00978)
Financial Leverage	-11.84512*** (0.15421)	-12.14582*** (0.14512)	-11.95412*** (0.10945)
Cash Holdings	5.45124***	6.45125***	4.84512***
Year Fixed Effects	Yes	Yes	Yes
Observations (N)	192,936	154,800	347,736
R-squared	0.6110	0.5528	0.5884
F-statistic	1148.87***	650.84***	1245.82***

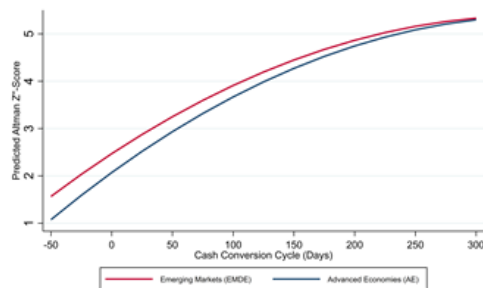


Figure 5: Comparative Fitted Solvency: Advanced Economies vs. Emerging Markets

Table 8 is a combination of life-cycle and institutional development. There is a significant difference in the coefficients obtained from the fits in each of the six cells and this is in favor of H4.

Overall, long operating cycles are more prevalent in mature companies in advanced economies, while short operating cycles are more prevalent among the declining companies in EMDEs. There are a number of sub-group vertices near to or on the support boundary so these differences should be considered relative tolerances, not operating limits.

Table 8

Variables	AE Growth	AE Mature	AE Decline	EMDE Growth	EMDE Mature	EMDE Decline
CCC	0.01476*** (0.00064)	0.01807*** (0.00067)	0.01906*** (0.00106)	0.01368*** (0.00051)	0.01831*** (0.00064)	0.01860*** (0.00094)
CCC Squared (CCC^2)	-0.0000196*** (0.0000019)	-0.0000221*** (0.0000021)	-0.0000265*** (0.0000031)	-0.0000207*** (0.0000015)	-0.0000297*** (0.0000018)	-0.0000302*** (0.0000026)
Firm Size (ln TA)	0.15505*** (0.01585)	0.10650*** (0.01650)	0.39177*** (0.03301)	-0.10718*** (0.01331)	-0.07424*** (0.01347)	-0.05792** (0.02648)
Financial Leverage	-9.57030*** (0.18530)	-11.60329*** (0.17875)	-12.74756*** (0.25119)	-10.22493*** (0.17935)	-12.68174*** (0.18384)	-14.83249*** (0.27677)
Cash Holdings	4.79568*** (0.27440)	6.00738*** (0.26017)	5.58562*** (0.34116)	7.16127*** (0.21730)	6.04648*** (0.29129)	4.95489*** (0.42183)
Operating ROA	0.26917*** (0.00632)	0.20019*** (0.00554)	0.37657*** (0.00674)	0.20913*** (0.00569)	0.18317*** (0.00543)	0.26823*** (0.00912)
Sales Growth	-0.00998*** (0.00070)	-0.01152*** (0.00073)	-0.00874*** (0.00098)	-0.00853*** (0.00055)	-0.00864*** (0.00061)	-0.00654*** (0.00087)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations (N)	44,312	88,606	29,998	39,250	65,661	25,291
R-squared	0.4799	0.5358	0.6354	0.5547	0.5621	0.5605
F-statistic	295.68***	454.85***	641.21***	448.92***	439.33***	285.01***

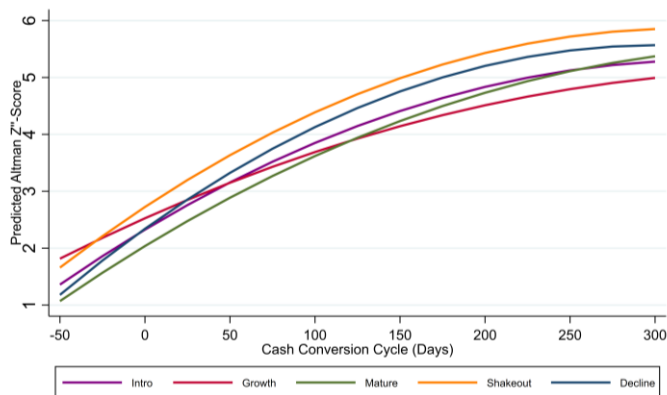


Figure 6: Fitted Solvency Profiles Across Corporate Life-Cycle Stages

Working-capital components

The CCC is decomposed in the Table 9. There are positive linear and negative squared relationships between DSI and DSO with Z". This aligns with the notion that if operating buffers are set too high, they are costly. But DPO is not like that: In the vast middle range there is a positive

correlation with distress and in the extreme range a negative one. That is an important economic imbalance. While trade credit can be beneficial for liquidity and maintaining the continuity of the trade link, it might suggest financing strain or inadequate bank credit availability or poor supplier relations if the credit terms are very lengthy (Gofman & Wu, 2022; Ersahin et al., 2024; Banking crises and corporate trade credit, 2024; Tang et al., 2025).

Table 9: Working-Capital Component Analysis: Inventory, Receivables, and Payables

Independent Variables	Model (1) Linear Z"	Model (2) Quadratic Z"	Model (3) Purged Z_adj	Model (4) Distress LPM
Days Sales of Inventory (DSI)	0.00881*** (0.00021)	0.01686*** (0.00056)	0.00758*** (0.00051)	-0.00132*** (0.00005)
DSI Squared (DSI^2)		-0.000025*** (0.0000016)	-0.000010** (0.0000015)	0.0000021*** (0.0000002)
Days Sales Outstanding (DSO)	0.01102*** (0.00029)	0.01996*** (0.00066)	0.00942*** (0.00060)	-0.00181*** (0.00006)
DSO Squared (DSO^2)		-0.000029*** (0.0000020)	-0.000012*** (0.0000018)	0.0000029*** (0.0000002)
Days Payables Outstanding (DPO)	-0.01910*** (0.00034)	-0.03993*** (0.00071)	-0.02801*** (0.00065)	0.00209*** (0.00006)
DPO Squared (DPO^2)		0.000073*** (0.0000022)	0.000052*** (0.0000020)	-0.0000035*** (0.0000002)
Optimal DSI (Days)		332.56***	379.00***	314.29***
Optimal DSO (Days)		338.36***	392.50***	312.07***
Optimal DPO (Days)		273.10***	269.33***	298.57***
Control Variables Included	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations (N)	329,056	329,056	329,056	329,056
R-squared	0.5835	0.5934	0.5247	0.3566
F-statistic	1503.13***	1407.88***	797.85***	954.55***

Endogeneity and robustness analyses

The endogeneity oriented tests are summarized in Table 10. The lagged-CCC model keeps both the positive linear term and negative quadratic term. The peer-IV specification allows for a positive association with the CCC and the dynamic panel still has considerable curvature. In a system that has GMM, the coefficient of the CCC term is positive but the quadratic term is not statistically

significant. These findings reinforce the conclusion that the working-capacity position relates to the solvency, but do not warrant a strong conclusion regarding a universal "optimal" nonlinear link. First stage strength alone can't establish the IV exclusion restriction and dynamic estimators are sensitive to persistence and instrument design.

Table 10: Endogeneity and Robustness Tests

Independent Variables	Model (1) Baseline OLS	Model (2) Lagged (t-1)	Model (3) 2SLS IV Peers	Model (4) Dynamic Panel	Model (5) System GMM
Lagged Z"-Score (Z_{t-1})				0.74222*** (0.00370)	0.64828*** (0.01183)
Cash Conversion Cycle (CCC)	0.01771*** (0.00039)	0.01730*** (0.00041)	0.00840*** (0.00173)	0.00370*** (0.00015)	0.00396*** (0.00074)
CCC Squared (CCC^2)	- 0.000025*** (0.000001)	- 0.000026*** (0.000001)		-0.0000041*** (0.0000004)	-0.0000010 (0.0000019)
Firm Size (ln Total Assets)	0.10850*** (0.00972)	0.09842*** (0.00985)	0.09602*** (0.01035)	-0.00095 (0.00295)	0.01993*** (0.00489)
Financial Leverage	- 11.88293*** (0.10949)	- 11.45214*** (0.11245)	- 12.02864*** (0.11420)	-3.48513*** (0.05601)	-4.97501*** (0.13256)
Cash Holdings	4.59871*** (0.15948)	4.21458*** (0.16124)	4.49501*** (0.16645)	2.44518*** (0.06481)	3.76159*** (0.09033)
Operating ROA	0.31891*** (0.00325)	0.29845*** (0.00341)	0.32824*** (0.00371)	0.13893*** (0.00158)	0.17470*** (0.00268)
Optimal CCC (Days)	355.29***	334.48***		455.54***	
First-Stage F-Statistic			1845.24***		
Arellano-Bond AR(1) (p-val)					0.000
Arellano-Bond AR(2) (p-val)					0.332
Hansen J Overid Test (p-val)					0.142
Number of Instruments			2		36
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations (N)	347,736	313,195	347,730	313,195	313,195
Number of Clusters (Firms)	25,258	24,303	25,254	24,303	24,303
R-squared	0.5846	0.5157	0.5786	0.8593	-

Discussion and implications

A very lean cycle can provide the cash, but can also reduce operating buffers, and subject companies to disturbances. Conversely, excess inventory and receivables can result in the need for increased financing and cash tied up.

The institutional findings also indicate the value of exercising care in transferring the working-capital target from one country to another. In more sophisticated financial systems, companies have more options for plugging short-term liquidity holes in their operating cycles, and companies in

emerging markets may be more likely to use internal liquidity and trade credit than the other operating tools. The DPO thus cannot be taken for granted as efficient free financing and should be considered in combination with other contractual terms and supplier dependence, bank credit and the financial distress indicators.

A fitted turning point based on an international panel does not constitute a treasury goal for any one company. Managers track data not part of the regression, such as product perishability, lead times, quality of customers' credit, terms of suppliers, seasonality, lines of credit from banks or chances for interruption in supply. The empirical curves should then be considered as evidence of financial consequences of working capital fluctuations in the distribution, rather than a sign of extension of CCC to a certain number of days.

This conditional interpretation is supported by the life-cycle evidence. During the introduction stage, the working-capital need poses a challenge in competition with investment and commercialization needs and can be a problem beforehand. For companies in decline, the most important thing to watch is the length of the inventory or receivables as this could be a sign of shrinking demand and poor collection practices. Therefore, life-cycle stage is not just an age classification but it alters the economic characteristics of the same balance-sheet amounts.

Although increasing DSI might signal a problem with supply, an excessive inventory also can signal potential sales or obsolescence issues. Late payment can save money in the short term, but also be an indicator of stress or hurtful to supplier relationships.

These results also have implications for supply-chain risk management. Payment delays by buyers may necessitate obtaining bank credit, lowering inventories, postponing or curtailing investments, or making tougher terms on other buyers. As a result, the monitoring of DPO in conjunction with the supplier concentration and supplier financial condition may provide a more accurate measure of resilience than the monitoring of the buyer's aggregate CCC.

If the CCC suddenly increases then the increase should be segregated into inventories, receivables, and payables before assessing the risk associated with the increase. Likewise, even if the aggregate CCC seems to be getting better, a sudden rise in DPO could be an indicator of a problem. From the empirical results, it is not possible to draw a rule for distress, but it is recommended to use Working Capital composition as a diagnostic tool, along with the profitability, leverage and cash holdings.

The interpretation is limited in several respects. First of all, Z'' and the distress dummy are not real events of bankruptcy, but indicators of accounting. Second, the analysis is of a descriptive nature. There are various endogeneity concerns addressed by the use of fixed effects, lags, IV specifications, and system GMM, but none makes the entire design equivalent to a randomized experiment. Third, the global sample is an amalgamation of firms with differing accounting practices, product structures, seasonality, and contractual practices.

Fourth, CCC bounds improve comparability and minimize the influence of extreme observations but they also have an impact on where a quadratic vertex can be estimated. Therefore, turning points near 365 days should be interpreted with consideration to the support. Fifth, life-cycle classification based on cash-flow signs carries some economic meaning, it can change the life-cycle position of the firm as financing and investment patterns evolve and it is not an organizational label. Lastly, the information available isn't directly indicative of contractually agreed or overdue long payable period.

Conclusion

The aim of this study is to investigate the link between working-capital policy and the financial health of a large international panel of companies. The baseline Z'' models are concave and the models for the distress zone are convex. Turning points are estimated and there are multiple of these in and around the documented support, so they should be interpreted as approximate markers of boundaries only and should not be considered as universal optimum points.

There is also significant variation in the evidence according to corporate life cycle, economic-development group and working-capital component. The longer the operating-cycle, the more tolerant are mature and advanced-economy firms while a shorter one is more tolerable among declining and EMDE firms. The relationships between inventory days, receivable days and solvency and between payable days and financial health are non-linear; the relationship between inventory days and solvency is non-linear and the relationship between payable days and financial health is non-linear for much of the economically relevant range. Lagged and dynamic models maintain the overall trend but IV and system-GMM estimates are not uniformly supportive of the quadratic turning point.

The results provide support for a context-dependent interpretation of working-capital fragility. CCC should be read in conjunction with the stage of the life cycle, the ability of the institutions to finance the project, and the structure of inventory, receivables and payables. Future research can expand analysis with the use of realized default outcomes, alternative distress measures, data on supply-chain relationships, and digital receivables-financing platforms.

The take-away from the study is that working capital management must be considered both as a resilience decision and an efficiency decision. The aggregate CCC is helpful because it is a summary of the timing of cash used in operations, but is much more informative if used in conjunction with the stage of development of the firm and the nature of the financing environment in which it operates and the individual behavior of its inventory, receivables and payables. Empirical evidence is thus not consistent with the view that one CCC value is generally desirable in all firms and countries.

In terms of research, the findings also highlight the need to interpret the results of nonlinear working-capital models in a support-aware manner. A vertex estimated statistically does not necessarily represent an economic optimum, especially if it falls near the edge of the sample or is

not produced if alternative identification strategies are used. Giving a shape fit report, observed support report, report on the variation of the subgroups and the robustness assessment of the curvature gives defensible interpretation rather than presenting just an estimated number, which is used as a managerial target. This is particularly significant in the case of the international samples where the operational practices and financing institutions vary significantly.

This framework can be extended in a number of directions for future research. Correlation of the operating cycle to default, restructuring, ratings change, bond spread and loan spread will be helpful to see if the accounting-based patterns convert to market and legal distress outcomes. Matching data from suppliers and customers could help to reveal how the financial pressure that comes from delayed payments flows through production networks. Invoice information can differentiate agreed trade-credit terms from over due obligations, data on factoring, supply-chain finance platforms and committed bank lines can provide insight into what makes it safer for companies to have longer operating cycles. This would further clarify the criteria for determining when working capital is productive operating slack and when it is a source of or symptom of financial fragility.

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