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Operating Liquidity, Firm Life Cycle, and Corporate Cash Adjustment: Evidence on Working Capital Dynamics Across Global Markets

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Abstract

This study systematically examines the association between working-capital strategy and cash holdings and cash-adjustment in the firm life cycle. The analysis is based on a global panel of 362,994 firm-year observations for 27,181 listed non-financial, non-utility firms in 134 economies for the period 2000-2025, and utilizes static quadratic regressions, dynamic partial-adjustment models, life-cycle subsamples, institutional splits, component decompositions, and robustness tests. The results indicate that the relationship between cash conversion cycle and cash/Assets is concave and cashAssets are negatively related to non-cash working capital, consistent with the liquidity-substitution interpretation. Dynamic models suggest high levels of cash ratios and lack of full-year adjustment, but the reported system-GMM specification is rejected by important diagnostic tests and is not considered to be confirmatory. Life-cycle and institutional analyses also reveal that curvature and adjustment speed of CCCs are not uniformly the same at different stages of the life cycle and in different markets. The overall results of the study can enrich the study of corporate liquidity, indicating that the configuration of working capital, cash reserves and the adjustment cost of the liquidity mode should be examined together instead of relying on a common CCC target.

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1. Introduction

In corporate finance, a central issue is corporate liquidity management; the companies have to keep their financial flexibility while continually funding inventories, receivables, payables, investment and operating commitments. Working-capital accounts are used to measure the time that it takes for operating activity to result in liquidity within the company, while cash holdings are used to safeguard against funding disruptions and unexpected shocks. These two options are thus related: Cash policy can not be understood without taking into consideration the cash conversion cycle (CCC), and the operating working capital configuration as a whole.

The theoretical prediction, however, is theoretically nuanced. The precautionary-cash theory states that the longer the operating cycle of a business, the greater the need for cash in that business, because cash flows are tied up in the business longer as inventory and customer credit are extended. The liquidity-substitution view, on the other hand, asserts that the cash

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flow of receivables, inventories and trade credit can replace the cash when these assets can be used in place of cash in the operations. Working capital and cash holdings can thus be related in a non-linear fashion and not always in a positive or a negative way.

This is particularly prominent in an international context. Access to bank credit, capital markets, factoring services, protection of creditors, and contract enforcement is different for firms in the advanced economies and emerging market and developing economies. Likewise, different companies have various financing needs, investment opportunities, and adjustment frictions at various stages of their life cycles. Depending on the situation, introduction and growth companies will need to maintain higher liquidity cushions to facilitate growth and uncertainty while mature companies may have to maintain higher liquidity cushions to support their cash flows and existing financing arrangements. These differences suggest that CCC-cash relation and the rate of cash adjustment could differ between the organisational levels and the institutional settings.

Several gaps in the literature have been identified, despite the many studies that have focused on cash holdings of corporations, their working-capital policy and the firm life-cycle. First, the literature frequently considers cash policy and working-capital policy to be independent decisions and there is relatively little evidence of how cash reserves are affected by the structure of the operating cycle. Second, many studies stress linear effects, as precautionary and substitution mechanisms suggest that there might be an inverted U-shaped relationship between CCC and cash holdings. Third, current data do not offer more comprehensive analysis of the cash adjustment speed at both the firm and institutional levels. The gaps serve as a motivation for a globally empirical analysis that relates working-capital configuration, target cash adjustment and heterogeneous liquidity friction.

This study addresses these gaps by examining 362,994 firm-year observations for 27,181 publicly listed non-financial, non-utility firms in 134 economies over 2000-2025. Empirical design includes static quadratic regressions, firm fixed effects, sector fixed effects, dynamic partial adjustment models, life-cycle subsampling based on Dickinson (2011), institutional groups based on IMF, firm component decompositions, lags specifications, and a peer-based instrumental-variable exercise. The design allows for the assessment of baseline association, nonlinear CCC effects, cash adjustment persistence, and cross sectional heterogeneity in the study, while being careful not to make too strong a causal interpretation.

The results indicate that the relation between the CCC and cash is concave for most of the static specifications, and that non-cash working capital is always negatively related to cash holding. Dynamic estimates show high cash ratios and that it takes a year or two for cash levels to reach their target ratio. It is also evidenced that the speed of adjustment varies from one life stage to another, as does the curvature of CCC.It is also found that there is variation in adjustment speed and CCC curvature from one life stage to another and from one institutional environment to another. The results here confirm that the cash policy is more of a set of liquidity architectures and not necessarily a target for the operating cycle.

The study makes three main contributions to the literature. First, it is useful to note that, in this regard, there is global evidence in large samples of the non-linear and conditional nature of the relation between CCC and corporate cash holdings. Second, it relates the working-capital configuration to dynamic target cash adjustments throughout the company's life cycle. Third, it demonstrates that the so-called ‘CCC-cash' relation is shaped by the development of institutions; specifically, the external financing conditions have an impact on corporate liquidity management. The remaining of the paper is organized as follows: In Section 2, the theoretical framework and hypotheses are developed. The methodology, the data, the variables and the empirical approach are described in Section 3. The empirical results are presented and elaborated on in Section 4. The policy implications, limitations and future research directions are included in the final section of the study.

2. Literature Review and Hypotheses Development

2.1. Corporate Cash Holdings and Working-Capital Liquidity

A theory of corporate cash holding suggests that firms will hold cash even though it does not pay off with a high return. Transaction requirements, financing constraints, external capital costs, and operating shock risk (Opler et al., 1999; Almeida et al., 2004; Han & Qiu, 2007) are all part of the trade-off and precautionary-cash arguments. In turn, this gives a reason to believe that companies with longer cash cycles will maintain higher levels of cash since inventory and commitments for receivables take longer to generate cash and the risk of short term funding is higher.

There is an alternative mechanism in working-capital theory. When the value of cash in hand can be collected, the value of inventories can be sold or collateralized, and the value of payables can be used to secure supplier financing, non-cash working capital can be used in part instead of cash. There is also some previous research that considers non-cash working capital as a liquidity substitute since it is a form of operating resources that can ease the requirement of cash balances. From the above two mechanisms it is suggested that the CCC-cash relationship may be positive at first but weakened or even turned negative at the stage of excess operating working capital.

This argument has been supported by recent studies, which indicate that the factors of operating liquidity, governance, profitability, and external shocks influence the formation of cash holdings. In India and Egypt, the correlation between cash reserves and firm performance and conditions in governance has been confirmed (Wellalage et al., 2023; Ali et al., 2024; Al Barak, 2025). These results support the opinion that cash is not usable separately from working capital management and profits performance of the firm.

Hypothesis 1a (Inverted U-shape): The relationship between the cash conversion cycle and corporate cash holdings is nonlinear and inverted U-shaped, such that cash holdings initially increase with CCC and then decrease after the turning point.

Hypothesis 1b (Liquidity substitution): Non-cash working capital is negatively associated with corporate cash holdings because operating working-capital assets substitute for cash reserves.

2.2. Dynamic Target Cash Reserves and Speed of Adjustment

Cash policy is also dynamic. The firms may have target cash ratios but factors like adjustment cost, information friction, transaction cost, and preferences of the firm can make it difficult to make a quick move towards the target cash ratio. Dynamic cash models thus forecast partial adjustment: firms adjust only a fraction of the shortfall in cash balances in each period. This conjecture is supported by the fact that the cash-adjustment behavior is found to differ across firms, cash-holding motivations, and financing constraints (Jiang & Wu, 2022).

Recent empirical evidence also suggests that cash holdings respond unevenly during different macroeconomic environments, differing managerial capabilities and during crises. Research on the speed of adjustment during booms and recessions, managerial skill in listed companies and learning in the COVID-19 period all indicate that firms adjust the speed of the rebalancing of liquidity when uncertainty, governance capacity, and prior cash-experience varies (Aflatooni et al., 2022; Bishal, 2023; Chireka & Moloi, 2023; Chung, 2023). The above studies can be used to support the approach of viewing speed of adjustment as an empirical outcome that varies from case to case and is a friction sensitive variable.

Hypothesis 2: Non-financial corporations partially adjust their cash holdings toward target cash ratios, implying a positive and economically meaningful speed of adjustment.

2.3. Firm Life Cycle and Liquidity Adjustment

Liquidity requirements and financing constraints vary throughout the life of a firm, according to the firm life-cycle theory. The business of introduction firms is characterized by fluctuating cash flows, poor credit records and high external financing requirements. Working capital is a need of the growth companies for expansion, investment opportunities, etc. Typically, a mature firm would have more stable cash flows and better access to external financing, while a shakeout or decline firm would have a potentially declining operating outlook and increased liquidity risk.

The differences point to a distinct relation between CCC and cash, as well as a different rate of adjustment to cash, at different life-cycle stages. Companies in more fragile positions could shift cash flows faster when there is a lack of funds, while more established companies might be able to adjust cash flows on a slower schedule since they have a more predictable cash flow from within. Previous research links firm life cycle to cash holding and working-capital targeting (Rehman et al., 2021; Seidu et al., 2022) but little research has investigated the moderating role of firm life cycle on the nonlinear relationship between cash and cash adjustment in a global context.

Hypothesis 3a: The CCC turning point differs across corporate life-cycle stages because the precautionary and substitution roles of working capital vary with firms' operating maturity and financing needs.

Hypothesis 3b: The speed of cash adjustment is higher among financially vulnerable Introduction and Decline firms and lower among Mature firms.

2.4. Institutional Development and Cross-Country Liquidity Frictions

Firms' access to external liquidity is influenced by country level institutions. Financial markets are generally deeper and more robust in advanced economies, and creditor protection is generally more robust, as is the development of the banking sector and the access of firms to financing from financial markets. Financing frictions are generally more pronounced in emerging market and developing economies, as are the levels of investor protection, and market infrastructure. These differences can lead to differing precautionary cash demand and the ability of firms to use working-capital accounts as liquidity substitutes.

Recent institutional and uncertainty-based studies also reveal that firms change cash policies as a result of institutional quality and macroeconomic uncertainty and market development changes. Institutional quality and external risk affect precautionary cash motives and excess cash decisions, as evidenced in Japan, and by cross-country epidemic exposure and economic-policy-uncertainty settings, respectively (Kim, 2023; Li et al., 2024; Yang et al., 2025). These more recent results support the institutional dichotomy between Advanced Economies and EMDE firms in the manuscript.

In the past years, there have been studies indicating that the cash-holding motives and cash-adjustment behaviors vary across institutional settings (Das et al., 2022; Akhtar, 2023; Tran & Nguyen, 2025). In more robust financial systems, companies can choose to have a lower level of precautionary cash for a given operating cycle since it is easier to access external financing. For weaker institutional environments, the liquidity buffers may need to be larger, and the cost of cash deviations greater, for longer CCC. It is important, therefore, that institutional development should have an impact on the form and turning point of the CCC-cash relation. Broader governance research also shows that resource wealth, managerial discipline, and corporate innovation are institutionally conditioned (Ghazali et al., 2026).

Hypothesis 4: The shape and turning point of the CCC-cash-holdings relation differ between Advanced Economies and Emerging Market and Developing Economies because external financing flexibility and institutional conditions differ across these environments.

3. Methodology

3.1. Data, Sample Construction, and Variable Measurement

The empirical analysis uses an unbalanced firm-year panel consisting of firms from Compustat Global and Compustat North America for the 2000-2025 fiscal year. It includes non-financial, non-utility corporations that are listed in the public markets for 134 economies. The exclusion of financial firms and regulated utilities from the category of operating corporations is because their cash balances, leverage and working-capital accounts are affected by a different set of statutory, liquidity and regulatory requirements when compared to the operating corporations. Any observations having either negative total assets, or non-positive total sales or total cash are dropped and continuous variables are winsorized at the 1st and 99th percentiles to minimize the impact of extreme accounting values.

The corporate cash-holdings ratio (CCE/TA) is the dependent variable. The cash conversion cycle (CCC) is the key working-capital indicator which measures the number of days that operating funds are tied up in inventories and receivables, net of the financing received in the form of payables from suppliers.

$$Cash_{\{i,t\}} = \frac{CCE_{\{i,t\}}}{TA_{\{i,t\}}} \qquad (1)$$

$$CCC_{\{i,t\}} = DSI_{\{i,t\}} + DSO_{\{i,t\}} - DPO_{\{i,t\}} \qquad (2)$$

$$DSI_{\{i,t\}} = \left(\frac{INV_{\{i,t\}}}{COGS_{\{i,t\}}}\right) * 365,\ DSO_{\{i,t\}} = \left(\frac{AR_{\{i,t\}}}{Sales_{\{i,t\}}}\right) * 365,\ DPO_{\{i,t\}} = \left(\frac{AP_{\{i,t\}}}{COGS_{\{i,t\}}}\right) * 365$$
(3)

To separate the operating-liquidity substitution channel from the length of the operating cycle, the study also measures non-cash net working capital. This variable captures the stock of working-capital resources other than cash and is expected to substitute for precautionary cash reserves when receivables, inventories, and supplier credit are available to support operations.

$$NWC_{\{i,t\}} = \frac{CA_{\{i,t\}} - Cash_{\{i,t\}} - CL_{\{i,t\}}}{TA_{\{i,t\}}} \qquad (4)$$

3.2. Baseline Econometric Specification

The first empirical specification estimates the association between working-capital policy and corporate cash holdings using a quadratic panel model. The quadratic term allows the CCC-cash relation to be nonlinear, which is central to the argument that cash needs initially rise with operating-cycle length but may decline when working-capital assets become large enough to act as liquidity substitutes. The vector X includes firm size, financial leverage, return on assets, capital expenditure, operating cash flow, and other standard determinants of cash holdings. Firm and year effects absorb time-invariant firm heterogeneity and common macroeconomic shocks where the specification requires them.

$$Cash_{\{i,t\}} = \alpha + \beta_{1CCC_{\{i,t\}}} + \beta_{2CCC^2_{\{i,t\}}} + \beta_{3NWC_{\{i,t\}}} + \gamma' X_{\{i,t-1\}} + \mu_i + \tau_t + \varepsilon_{\{i,t\}} \qquad (5)$$

In Equation (5), a positive β1 and negative β2 indicate a concave relation between CCC and cash holdings. The implied CCC turning point is calculated only when the estimated curvature is economically meaningful and statistically interpretable.

$$CCC^* = -\frac{\beta_1}{2\beta_2} \qquad (6))$$

3.3. Dynamic Partial Adjustment Model

Because firms do not instantly adjust to their desired cash positions, the study estimates dynamic partial-adjustment models. The target cash ratio is treated as a function of working-capital structure, firm characteristics, life-cycle position, and institutional conditions. The adjustment parameter lambda measures the annual speed with which firms close the gap between actual and target cash holdings.

$$Cash_{\{i,t\}} - Cash_{\{i,t-1\}} = \lambda\left(Cash^*_{\{i,t\}} - Cash_{\{i,t-1\}}\right) + \varepsilon_{\{i,t\}} \qquad (7)$$

The estimable dynamic specification includes lagged cash holdings. If rho is the coefficient on lagged cash, the implied speed of adjustment is one minus ρ. Higher SOA values indicate faster rebalancing toward the target cash ratio, while lower values indicate stronger adjustment frictions.

$$Cash_{\{i,t\}} = \alpha + \rho Cash_{\{i,t-1\}} + \beta_{1CCC_{\{i,t\}}} + \beta_{2CCC^2_{\{i,t\}}} + \beta_{3NWC_{\{i,t\}}} + \gamma' X_{\{i,t-1\}} + \mu_i + \tau_t + \varepsilon_{\{i,t\}} \quad (8)$$

$$SOA = \lambda = 1 - \rho \quad (9)$$

3.4. Firm Life-Cycle and Institutional Moderation

Firm life-cycle stages are classified using the Dickinson (2011) cash-flow pattern approach, which assigns firms to introduction, growth, maturity, shakeout, or decline according to the signs of operating, investing, and financing cash flows. This classification is used to test whether the CCC-cash relation and adjustment speed differ across organizational maturity. The life-cycle model interacts CCC and CCC squared with stage indicators, allowing both the slope and curvature of the cash-working-capital relation to vary by stage.

$$Cash_{\{i,t\}} = \alpha + \Sigma_s \delta_{sLC^s_{\{i,t\}}} + \Sigma_s \theta_{s\left(CCC_{\{i,t\}} * LC^s_{\{i,t\}}\right)} + \Sigma_s \varphi_{s\left(CCC^2_{\{i,t\}} * LC^s_{\{i,t\}}\right)} + \beta NWC_{\{i,t\}} + \gamma' X_{\{i,t-1\}} + \mu_i + \tau_t + \varepsilon_{\{i,t\}} \quad (10)$$

The institutional analysis separates advanced economies from emerging market and developing economies using IMF macroeconomic classification. This split captures differences in external financing access, creditor protection, market depth, and institutional quality. The institutional-interaction model tests whether the shape of the CCC-cash profile differs between the two macroeconomic groups.

$$Cash_{\{i,t\}} = \alpha + \beta_{1CCC_{\{i,t\}}} + \beta_{2CCC^2_{\{i,t\}}} + \beta_{3AE_c} + \beta_{4(CCC_{\{i,t\}} * AE_c)} + \beta_{5\left(CCC^2_{\{i,t\}} * AE_c\right)} + \beta_{6NWC_{\{i,t\}}} + \gamma' X_{\{i,t-1\}} + \mu_i + \tau_t + \varepsilon_{\{i,t\}} \quad (11)$$

3.5. Robustness and Identification Strategy

Several additional specifications are used to assess whether the findings are driven by model choice, timing, omitted firm heterogeneity, or dynamic-panel bias. The robustness suite includes pooled OLS, sector and year fixed effects, firm fixed effects, lagged explanatory variables, dynamic OLS, peer-based instrumental-variable specifications, and two-step system GMM. The instrumental-variable design uses industry-year peer CCC as an excluded instrument for a firm's own CCC, while the GMM models use internal lags to address persistence and potential simultaneity.

$$CCC_{\{i,t\}} = \pi_0 + \pi_{1PeerCCC_{\{j,-i,t\}}} + \pi' X_{\{i,t-1\}} + \nu_i + \tau_t + u_{\{i,t\}} \quad (12)$$

$$Cash_{\{i,t\}} = \alpha + \beta_{1CCC^{IV}_{\{i,t\}}} + \beta_2 * \left(CCC^{IV}_{\{i,t\}}\right)^2 + \beta_{3NWC_{\{i,t\}}} + \gamma' X_{\{i,t-1\}} + \mu_i + \tau_t + \varepsilon_{\{i,t\}} \quad (13)$$

The system-GMM estimates are interpreted cautiously because valid inference requires no second-order serial correlation and acceptable overidentifying-restriction diagnostics.

Consequently, the dynamic and instrumental-variable models are used as robustness and triangulation exercises rather than as the sole basis for causal claims.

3.6. Data Description and Preliminary Evidence

Table 1 summarizes the sample composition across economic groups, life-cycle stages, and cash-reserve quartiles. Advanced economies account for 54.86% of the observations and report higher average cash ratios than EMDE firms, while decline-stage firms display the highest mean cash ratio among the life-cycle groups.

Table 1. Sample Composition and Distribution Across Economies, Corporate Life Cycles, and Cash Reserves (2000–2025)

Classification Dimension / Subgroup	Firm-Years (N)	Percent (%)	Mean Cash Ratio	SD Cash Ratio
Panel A: Macroeconomic Institutional Groups				
Advanced Economies (AE)	199,135	54.86%	0.1462	0.1382
Emerging Markets & Developing Economies (EMDE)	163,859	45.14%	0.1094	0.1236
Full Global Sample Total	362,994	100.00%	0.1296	0.1331
Panel B: Dickinson (2011) Life-Cycle Stages				
Introduction Stage (FLCS = 1)	46,969	12.94%	0.1246	0.1491
Growth Stage (FLCS = 2)	87,668	24.15%	0.1295	0.1289
Mature Stage (FLCS = 3)	159,737	44.01%	0.1238	0.1216
Shakeout Stage (FLCS = 4)	10,756	2.96%	0.1238	0.1382
Decline Stage (FLCS = 5)	57,864	15.94%	0.1513	0.1514
Full Life-Cycle Sample Total	362,994	100.00%	0.1296	0.1331
Panel C: Cash Holdings Quartiles	Firm-Years (N)	Mean Cash	Mean CCC (days)	Mean NWC/Assets
Quartile 1 (Lowest Cash Reserves)	90,749	0.0163	114.86	0.0592
Quartile 2 (Low-Medium Cash Reserves)	90,748	0.0577	104.87	0.0763

Quartile 3 (Medium-High Cash Reserves)	90,749	0.1274	103.48	0.0706
Quartile 4 (Highest Cash Reserves)	90,748	0.3171	93.54	0.0526

Note. This table presents the composition of the global sample across 134 economies spanning fiscal years 2000 through 2025. Financial institutions (GICS 40) and regulated utilities (GICS 55) are excluded. Macroeconomic classification follows the IMF World Economic Outlook (AE = 1, EMDE = 0). Corporate life-cycle stages are classified using Dickinson's (2011) cash-flow pattern methodology. Cash holdings ratio is cash and cash equivalents scaled by total assets. Cash conversion cycle (CCC) is measured in days.

Table 2 reports the distribution of the main financial and operating variables, and Table 3 presents the correlation matrix and VIF diagnostics. The low pairwise correlations and VIF values indicate that the baseline covariates do not create a material multicollinearity concern.

Table 2. Descriptive Statistics of Key Financial, Operational, and Life-Cycle Variables

Variable Description	N	Mean	SD	p25	Median	p75	Min	Max
Cash Holdings Ratio (Cash/Assets)	362,994	0.130	0.133	0.033	0.087	0.180	0.001	0.648
Net Working Capital less Cash / Assets	362,994	0.065	0.219	-0.048	0.065	0.192	-0.808	0.609
Cash Conversion Cycle (days)	362,994	104.187	110.592	31.800	81.400	151.200	-100.000	365.000
Days Sales of Inventory (days)	348,120	92.095	83.586	32.700	69.500	123.000	0.000	365.000
Days Sales Outstanding (days)	360,415	74.667	62.993	34.500	60.400	95.300	0.000	365.000
Days Payables Outstanding (days)	356,280	71.531	63.525	31.600	54.000	88.800	0.000	365.000
Firm Size (ln Total Assets)	362,994	12.136	2.096	10.752	12.073	13.462	7.091	17.452

Financial Leverage (Total Debt / Assets)	362,994	0.233	0.203	0.060	0.201	0.354	0.000	1.001
Return on Assets (%)	362,994	2.911	8.286	0.800	3.340	6.470	-43.730	22.930
Sales Growth Rate (%)	362,994	11.566	33.312	-4.130	6.900	21.410	-67.280	162.630
Capital Expenditures / Assets	354,625	0.047	0.052	0.011	0.029	0.062	0.000	0.275
Operating Cash Flow / Assets	362,994	0.062	0.089	0.018	0.061	0.111	-0.325	0.352

Note. All continuous variables are winsorized at the 1st and 99th percentiles to mitigate outlier distortion. The sample comprises 362,994 firm-year observations across 27,181 non-financial and non-utility firms from 134 economies spanning 2000–2025.

Table 3. Pearson Correlation Matrix and Variance Inflation Factor (VIF) Multicollinearity Diagnostics

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	VIF	1/VIF
(1) Cash Holdings Ratio	1.000										
(2) Cash Conversion Cycle (days)	-0.070*	1.000								1.30	0.772
(3) Net Working Capital less Cash / Assets	-0.037*	0.407*	1.000							1.64	0.609
(4) Firm Size	-0.070*	-0.065*	-0.084*	1.000						1.08	0.927
(5) Financial Leverage	-0.343*	-0.012*	-0.439*	0.075*	1.000					1.31	0.763
(6) Return on Assets (%)Return on Assets (%)	-0.039*	-0.023*	0.251*	0.225*	-0.189*	1.000				1.21	0.824
(7) Sales Growth Rate (%)	0.039*	-0.069*	0.020*	-0.015*	-0.021*	0.157*	1.000			1.06	0.944

(8) Capital Expenditures / Assets	-0.096*	-0.156*	-0.122*	0.014*	0.064*	0.136*	0.120*	1.000		1.13	0.884
(9) FLCS	0.051*	0.005*	0.033*	-0.007*	-0.117*	0.039*	-0.136*	-0.237*	1.000	1.10	0.906
Mean VIF										1.23	

Note. * indicates statistical significance at the 5% level ($p < 0.05$). Variance Inflation Factors are based on the baseline covariate set. All VIFs are below 2.0 (mean VIF = 1.23), indicating no material multicollinearity concern.

4. Empirical Results and Their Discussion

The correlation between working-capital management and cash holdings of the companies is summarized in Table 4. The linear models have small positive CCC coefficients, whereas the quadratic specifications show a curvature to economic meaning. In Model 3, CCC is positive (0.000093, $p < 0.001$) and CCC^2 is negative (-0.00254 on $CCC^2/10^4$, $p < 0.001$), implying a turning point of 182.22 days. The respective vertices are 201.50 days with sector and year effects, 166.15 days with firm fixed effects. All three estimates fall within the range of -100 to 365 days that is observed in the CCC so the concave pattern is more plausible than a single universal threshold.

There is a substantive significance to the movement in the turning point across specifications. Reading the estimated peak from the sector controls increases it by approximately 19 days compared to reading the peak from Model 3, and firm fixed effects decrease the estimated peak by approximately 16 days compared to reading the peak from Model 3. These results confirm the hypothesis of nonlinearity but also indicate that the position of the peak at the peak center is highly dependent on the estimator. Figure 1 depicts just the part of the covariate vector which is related to the CCC, yielding the misleading level of the absolute 'predicted cash' when this is not shown.

Liquidity substitution is consistently the case when considering non-cash working capital, which is negative across all five models (-0.1483 to -0.1554 in the principal pooled specifications and -0.1538 with firm fixed effects). There is also a negative relationship between cash holdings and leverage and capital expenditures. These estimates do not provide evidence, per se, that firms should aim at the reported turning point, rather they are conditional associations.These estimates are conditional associations, and do not convey evidence in themselves that firms should aim at the reported turning point.

Table 4. Baseline Static Regressions: Impact of Working Capital Management on Corporate Cash Holdings

Independent Variables	(1) Pooled Linear OLS	(2) Linear + Year FE	(3) Quadratic + Year FE	(4) Sector & Year FE	(5) Firm Fixed Effects
Cash Conversion Cycle (CCC)	0.000020*** (0.000005)	0.000013* (0.000005)	0.000093*** (0.000012)	0.000073*** (0.000012)	0.000070*** (0.000010)

CCC Squared (CCC^2 / 10^4)			-0.00254*** (0.00032)	-0.00181*** (0.00033)	-0.00211*** (0.00027)
Non-Cash NWC / Assets	-0.1507*** (0.0032)	-0.1483*** (0.0032)	-0.1525*** (0.0032)	-0.1554*** (0.0031)	-0.1538*** (0.0029)
Firm Size (ln Assets)	-0.0030*** (0.0003)	-0.0035*** (0.0003)	-0.0034*** (0.0003)	-0.0026*** (0.0003)	-0.0073*** (0.0006)
Financial Leverage	-0.2998*** (0.0033)	-0.2968*** (0.0033)	-0.2975*** (0.0033)	-0.2765*** (0.0032)	-0.1903*** (0.0030)
Return on Assets (ROA)	-0.0007*** (0.0001)	-0.0006*** (0.0001)	-0.0007*** (0.0001)	-0.0003*** (0.0001)	0.0017*** (0.0001)
Sales Growth	0.0002*** (0.0000)	0.0002*** (0.0000)	0.0002*** (0.0000)	0.0002*** (0.0000)	-0.0000** (0.0000)
Capital Expenditures (CapEx)	-0.2403*** (0.0074)	-0.2233*** (0.0074)	-0.2247*** (0.0074)	-0.2032*** (0.0072)	-0.1079*** (0.0047)
Constant	0.2547*** (0.0039)	0.2415*** (0.0039)	0.2387*** (0.0040)	0.2426*** (0.0053)	0.2574*** (0.0072)
Optimal CCC Turning Point			182.22 days***	201.50 days***	166.15 days***
Year Fixed Effects	No	Yes	Yes	Yes	Yes
Industry Sector Fixed Effects	No	No	No	Yes	No
Firm Fixed Effects	No	No	No	No	Yes
Clustering (Firm Level)	Yes	Yes	Yes	Yes	Yes
Observations (N)	354,625	354,625	354,625	354,572	354,625
R-squared	0.1820	0.1893	0.1902	0.2298	0.1088 (Within)

F-statistic	1311.55***	400.46***	390.55***	353.82***	269.61***

Note. The dependent variable is corporate cash holdings (Cash/Assets). Clustered standard errors at the firm level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The optimal CCC turning point is computed via delta-method: -beta1 / (2*beta2).

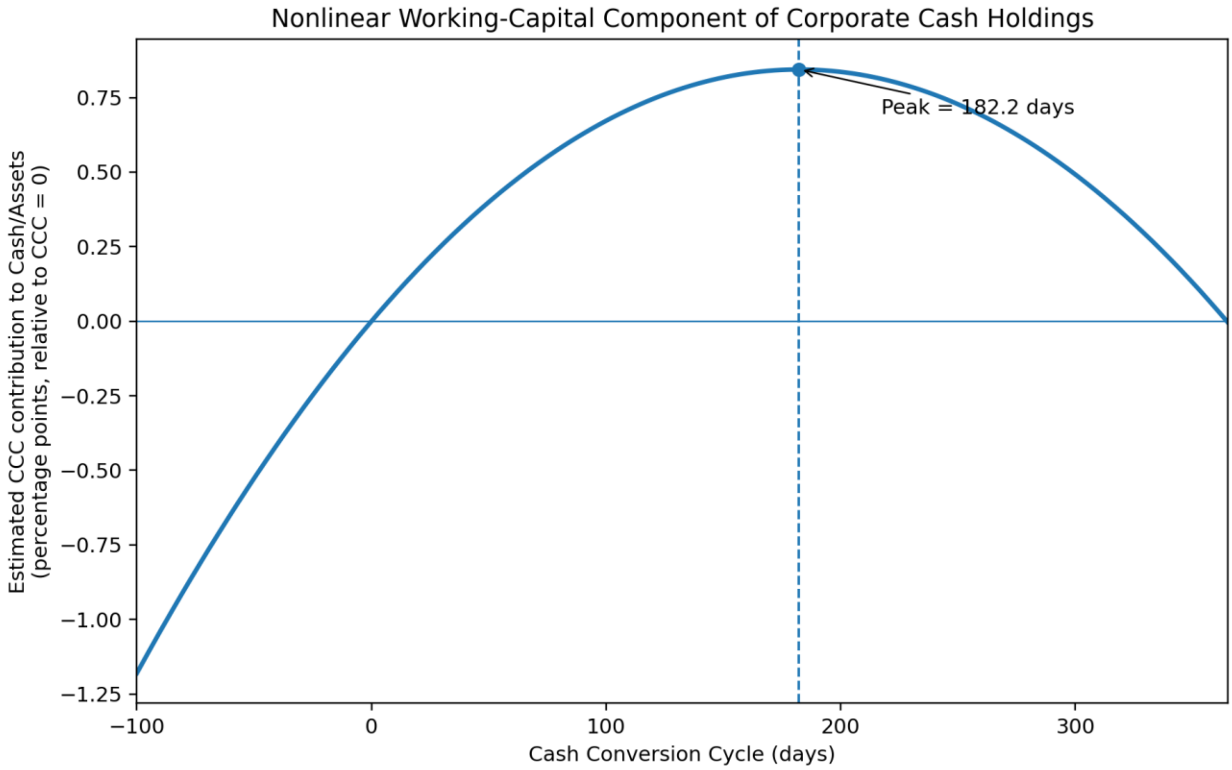

Figure 1: ***Nonlinear Working-Capital Component of Corporate Cash Holdings***

4.1. Dynamic Partial Adjustment Models and Speed of Cash Adjustment

The next table, Table 5, examines cash persistence through dynamic partial adjustment specifications. The lagged cash coefficient is between 0.77 and 0.78, with a corresponding implied annual adjustment rate of approximately 22%–23% and half-life of about 2.6–2.7 years, in Models 1–3. The lag coefficient obtained from the within-firm dynamic model is much smaller, 0.4770, which indicates that the implied adjustment speed of the dynamic model is very high, at 52.30%. The large range in the estimates of the width of the estimators demonstrates the influence of the persistence of firm heterogeneity.

The dynamic estimates are NOT to be interpreted mechanically. Pooled dynamic OLS can be biased due to unobserved firm effects, and the within-firm estimator can have Nickell bias in finite-T panels. This suggests that these models offer evidence of persistence and partial adjustment of cash ratios and not a uniquely determined structural speed of adjustment.

The two-step system GMM results obtained from Model 5 are around 0.7166, which gives an SOA of 28.34%. The absence of a second-order serial correlation, as well as the Hansen overidentifying restrictions, are, however, rejected by the reported diagnostics (both at AR(2) $p < 0.001$ and Hansen $p < 0.001$). The GMM specification is thus found to be invalid in several important respects and is recommended not to be used as the estimator of preference but as a sensitivity estimate only. In the limited sense that all reported dynamic models exhibit significant persistence and they do not allow for full annual adjustment, Hypothesis 2 is supported.

Table 5. Dynamic Partial Adjustment Models and Speed of Cash Adjustment (SOA) Across Estimators

Independent Variables	(1) Dynamic OLS	(2) Dynamic + Year FE	(3) Sector & Year FE	(4) Within-Firm FE	(5) Two-Step System GMM
Lagged Cash Ratio (Cash_{t-1})	0.7762*** (0.0021)	0.7760*** (0.0021)	0.7652*** (0.0022)	0.4770*** (0.0034)	0.7166*** (0.0090)
Cash Conversion Cycle (CCC)	0.000061*** (0.000004)	0.000062*** (0.000004)	0.000055*** (0.000004)	0.000063*** (0.000007)	0.000104*** (0.000006)
CCC Squared ($CCC^2 / 10^4$)	-0.00133*** (0.00011)	-0.00136*** (0.00011)	-0.00111*** (0.00012)	-0.00155*** (0.00019)	-0.00197*** (0.00015)
Non-Cash NWC / Assets	-0.0812*** (0.0013)	-0.0807*** (0.0013)	-0.0825*** (0.0013)	-0.1413*** (0.0024)	-0.1399*** (0.0020)
Controls (Size, Lev, ROA, Growth, CapEx)	Yes	Yes	Yes	Yes	Yes
Constant	0.0792*** (0.0013)	0.0761*** (0.0015)	0.0772*** (0.0018)	0.1821*** (0.0052)	0.1172*** (0.0026)
Speed of Adjustment (SOA: lambda)	22.38%***	22.40%***	23.48%***	52.30%***	28.34%***
Implied Half-Life (years)	2.74 yrs	2.73 yrs	2.59 yrs	0.94 yrs	2.08 yrs
Fixed Effects	None	Year	Sector + Year	Firm + Year	Year
Instruments Count					33 (Collapsed)
Arellano-Bond AR(1) p-value					< 0.001

Arellano-Bond AR(2) p-value					< 0.001
Hansen J Overidentification p-value					< 0.001
Observations (N)	319,398	319,398	319,349	319,398	319,398
R-squared / Wald Chi^2	0.6946	0.6963	0.6983	0.3322 (Within)	15,718.15*** (Chi^2)

Note. Dynamic partial-adjustment models. Speed of adjustment is $\lambda = 1 - \beta(Cash_{t-1})$; half-life is $\ln(0.5)/\ln[\beta(Cash_{t-1})]$. Model 5 reports two-step system GMM with collapsed instruments, but its AR(2) and Hansen tests both have $p < 0.001$; the GMM estimates are therefore reported as sensitivity evidence rather than a valid confirmatory specification. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4.2. Corporate Life-Cycle Moderation of Cash Holdings and Adjustment

Table 6 reveals that there is substantial life-cycle heterogeneity both in terms of cash persistence and curvature of CCC. The implied SOA is highest in Introduction (35.88%), drops to 22.37% in Growth, reaches its lowest point in Mature (19.11%) and then increases to 22.84% in Shakeout and 24.49% in Decline. This pattern is in line with general expectations of Hypothesis 3b: that cash policy is slowest in the Mature stage of the firms and changes most frequently in less stable stages.

The turning points for the CCC are also different for each stage. The vertex is the largest statistically supported value among the growth firms (319.08 days), followed by Introduction (268.46), Mature (204.70) and Decline (148.83). The linear CCC term is not statistically significant and the reported turning point is not statistically significant, so the report of a turning point should not be considered an identified optimum. Therefore the evidence is consistent with life cycle heterogeneity but not a strict progression through all five stages.

The figures for adjustment speeds are summarized in Figure 2, not the turning points. What's apparent from the visual result is that the slowest annual adjustment is shown by the mature firms, and the fastest adjustment by the Introduction firms. This is a more defensible graphical summary than the original life-cycle fitted curves that were not separately reported in a pooled interaction model.

Table 6. Corporate Life-Cycle Moderation of Cash Holdings and Dynamic Adjustment Frictions

Independent Variables	(1) Introduction	(2) Growth	(3) Mature	(4) Shakeout	(5) Decline
Lagged Cash Ratio (Cash_{t-1})	0.6412*** (0.0063)	0.7763*** (0.0041)	0.8089*** (0.0025)	0.7716*** (0.0097)	0.7551*** (0.0045)

Cash Conversion Cycle (CCC)	0.000048*** (0.000013)	0.000079*** (0.000008)	0.000076*** (0.000005)	0.000013 (0.000020)	0.000034** (0.000011)
CCC Squared (CCC^2 / 10^4)	-0.00090** (0.00032)	-0.00124*** (0.00021)	-0.00186*** (0.00013)	-0.00106* (0.00052)	- 0.00115*** (0.00028)
Non-Cash NWC / Assets	-0.0470*** (0.0030)	-0.1051*** (0.0027)	-0.0751*** (0.0016)	-0.0494*** (0.0048)	-0.0937*** (0.0029)
Controls (Size, Lev, ROA, Growth, CapEx)	Yes	Yes	Yes	Yes	Yes
Constant	0.0305*** (0.0048)	0.1165*** (0.0032)	0.0562*** (0.0016)	0.0533*** (0.0090)	0.0796*** (0.0041)
Optimal CCC Turning Point	268.46 days***	319.08 days***	204.70 days***	61.11 days	148.83 days***
Speed of Adjustment (SOA: lambda)	35.88%***	22.37%***	19.11%***	22.84%***	24.49%***
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Clustering (Firm Level)	Yes	Yes	Yes	Yes	Yes
Observations (N)	39,120	76,539	145,945	9,151	48,643
R-squared	0.6018	0.6458	0.8220	0.6700	0.6453
F-statistic	673.34***	2377.01***	6278.77***	348.23***	1755.48***

Note. Life-cycle subsample regressions. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Turning points represent optimal CCC peaks computed via delta method.

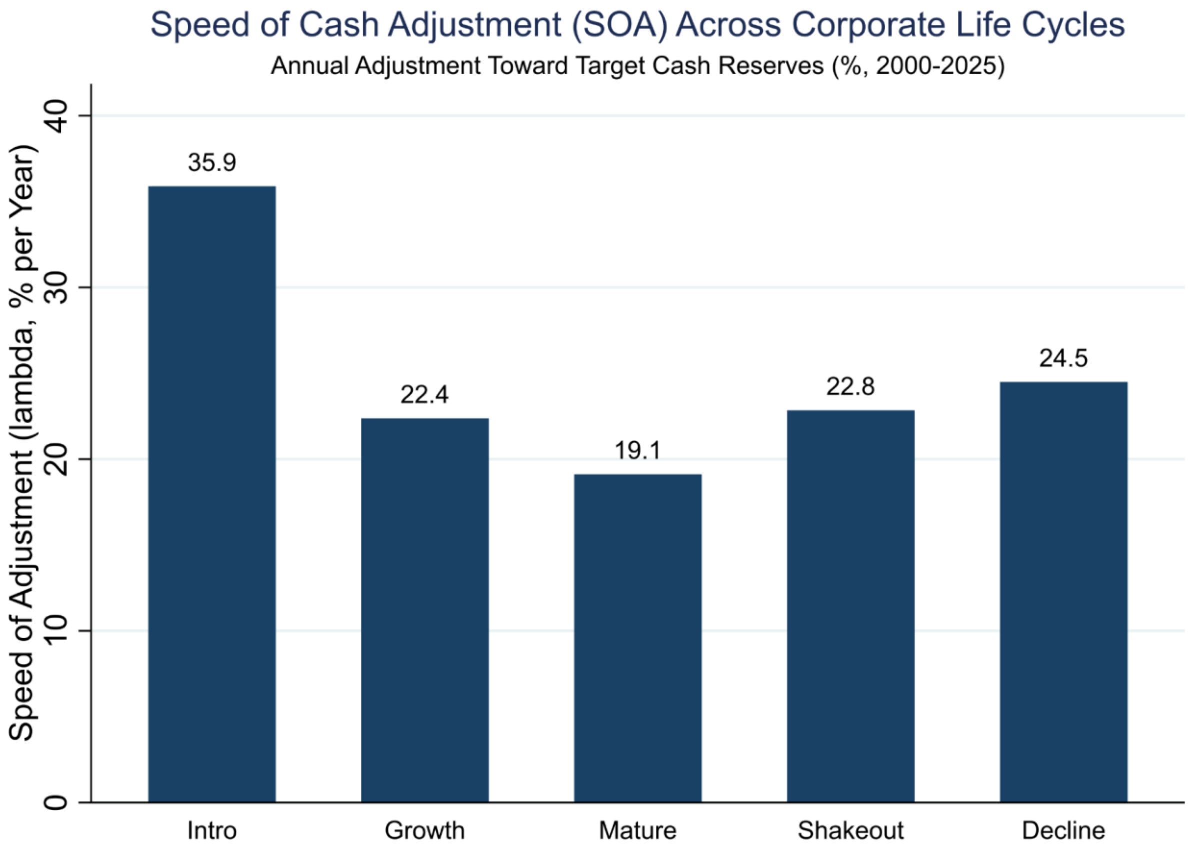

Figure 2: *Speed of Cash Adjustment Across Corporate Life-Cycle Stages*

4.3. Macroeconomic Institutional Divide and the Core Triple Interaction

Table 7 shows that cash levels and CCC curvature are affected by the setting of institutions. When fit separately in dynamic regressions, the estimated CCC vertices for Advanced Economies and EMDE firms are 346.68 days and 267.17 days respectively, and the adjustment rate of these dynamic regressions is similar for both set of firms (23.40% and 24.92%). These are subgroups point estimates without a formal test of the difference across subgroups in nonlinear turning points and should thus be interpreted descriptively and not as a tested difference in thresholds for the groups.

Table 7. Institutional Development Divide: Advanced Economies versus Emerging Markets

Independent Variables	(1) Advanced Economies (AE)	(2) Emerging Markets (EMDE)	(3) Full Sample Interactive
Lagged Cash Ratio (Cash_{t-1})	0.7660*** (0.0030)	0.7508*** (0.0031)	0.7704*** (0.0021)
Cash Conversion Cycle (CCC)	0.000038*** (0.000006)	0.000081*** (0.000005)	0.000079*** (0.000005)

CCC Squared (CCC² / 10⁴)	-0.00055** (0.00017)	-0.00152*** (0.00014)	-0.00173*** (0.00014)
CCC × Advanced Economy (CCC × AE)			-0.000038*** (0.000007)
CCC² × Advanced Economy (CCC² × AE / 10⁴)			0.00143*** (0.00022)
Advanced Economy Indicator (AE = 1)			0.0105*** (0.0005)
Non-Cash NWC / Assets	-0.0809*** (0.0019)	-0.0847*** (0.0018)	-0.0832*** (0.0013)
Controls (Size, Lev, ROA, Growth, CapEx)	Yes	Yes	Yes
Constant	0.1099*** (0.0023)	0.0465*** (0.0021)	0.0753*** (0.0015)
Optimal CCC Turning Point	346.68 days***	267.17 days***	—
Speed of Adjustment (SOA: lambda)	23.40%***	24.92%***	22.42%***
Year Fixed Effects	Yes	Yes	Yes
Clustering (Firm Level)	Yes	Yes	Yes
Observations (N)	176,654	142,744	319,398
R-squared	0.7057	0.6801	0.6975
F-statistic	4724.79***	4195.97***	7854.37***

Note. Models 1 and 2 split the sample by IMF economic group (AE versus EMDE); Model 3 estimates the pooled interaction. The separate-subsample turning points are not accompanied by a formal test of the difference between vertices. Dependent variable: Cash/Assets. Firm-clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The pooled interaction in Table 7 is also substantively informative. Both CCC×AE and CCC²×AE are significant, implying a flatter CCC profile for AE firms than for EMDE firms. Combining the Model 3 coefficients gives an implied EMDE vertex of roughly 228 days, whereas the AE vertex lies well beyond the observed CCC range. Figure 3 reflects this pooled-interaction parameterization: the EMDE curve is visibly concave over the sample range, while the AE profile remains comparatively flat and increasing. The difference from the separate-subsample vertices illustrates model sensitivity rather than a contradiction.

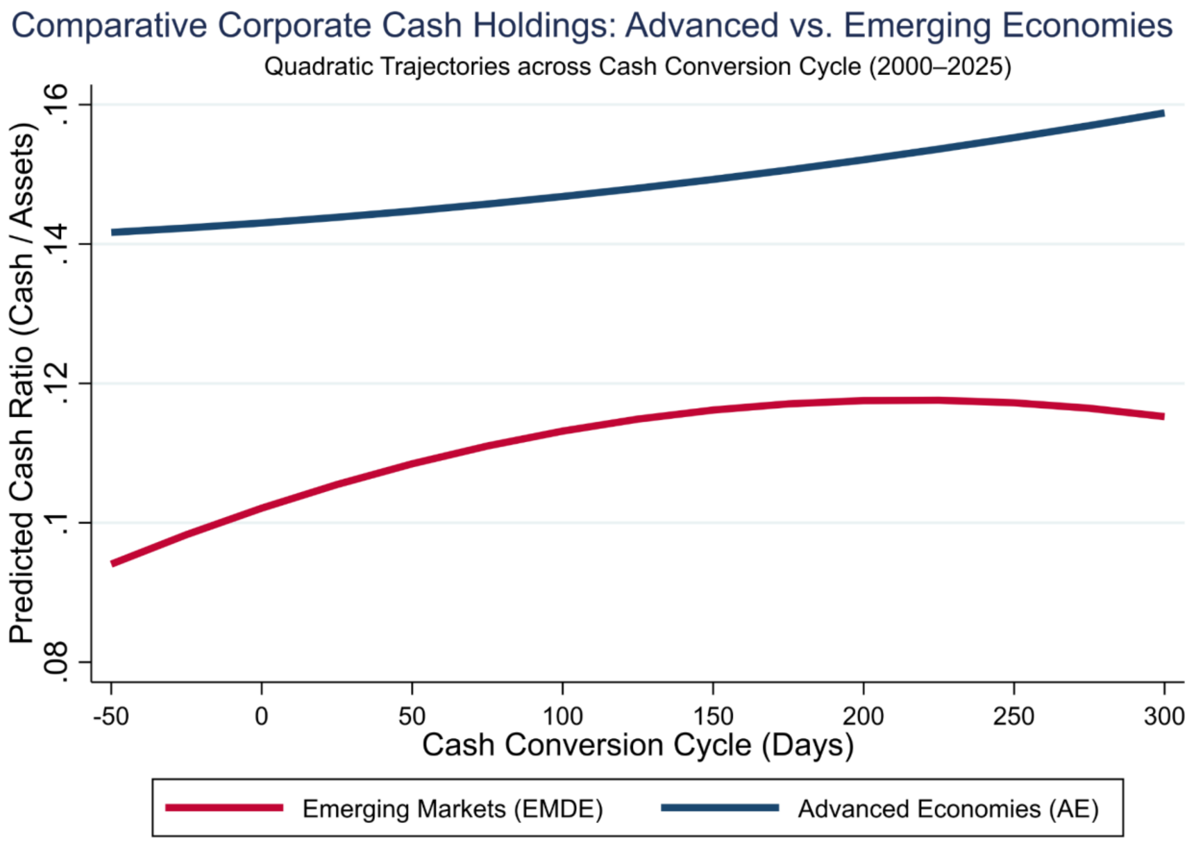

Figure 3: *Corporate Cash-Holdings Profiles by Institutional Development*

Table 8 provides a finer six-regime split. The strongest nonlinear evidence appears for AE Mature firms and for EMDE Growth, Mature, and Decline firms, where both the relevant CCC terms support concavity. By contrast, AE Growth has an insignificant quadratic term and an implied vertex of 490.89 days, outside the observed upper CCC bound of 365 days; AE Decline also has insignificant linear and quadratic CCC terms. These two turning points should not be described as identified optima.

Among the statistically supported regimes, AE Mature firms have a turning point of 284.15 days and the slowest adjustment speed in Table 8 (17.70%). EMDE Growth, Mature, and Decline firms have supported vertices of 276.19, 239.80, and 265.67 days, respectively, with SOAs between 23.17% and 25.91%. The six-way results therefore support joint heterogeneity in cash policy, but they do not validate the original ranking that treated AE Growth as the global optimum.

Across every institutional-life-cycle regime, non-cash working capital remains negative and statistically significant. This is one of the most stable results in the paper and reinforces the view that operating working-capital assets substitute for cash even when the CCC curvature itself varies across stages and countries.

Table 8. The Core Triple Interaction: Corporate Life Cycle and Macroeconomic Institutional Divide

Independent Variables	(1) AE Growth	(2) AE Mature	(3) AE Decline	(4) EMDE Growth	(5) EMDE Mature	(6) EMDE Decline
Lagged Cash Ratio (Cash_{t-1})	0.7737*** (0.0058)	0.8230*** (0.0033)	0.7272*** (0.0064)	0.7563*** (0.0062)	0.7683*** (0.0038)	0.7409*** (0.0070)
Cash Conversion Cycle (CCC)	0.000031** (0.000011)	0.000076*** (0.000007)	0.000013 (0.000017)	0.000122*** (0.000011)	0.000066*** (0.000007)	0.000039** (0.000013)
CCC Squared (CCC^2 / 10^4)	-0.00032 (0.00032)	-0.00134*** (0.00020)	-0.00020 (0.00046)	-0.00220*** (0.00030)	-0.00137*** (0.00018)	-0.00073* (0.00033)
Non-Cash NWC / Assets	-0.0859*** (0.0035)	-0.0745*** (0.0022)	-0.0985*** (0.0045)	-0.1200*** (0.0041)	-0.0786*** (0.0023)	-0.1006*** (0.0037)
Controls (Size, Lev, ROA, Growth, CapEx)	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.1452*** (0.0043)	0.0741*** (0.0023)	0.1275*** (0.0065)	0.0904*** (0.0048)	0.0425*** (0.0025)	0.0587*** (0.0054)
Optimal CCC Turning Point	490.89 days	284.15 days***	322.38 days	276.19 days***	239.80 days***	265.67 days***
Speed of Adjustment (SOA: lambda)	22.63%***	17.70%***	27.28%***	24.37%***	23.17%***	25.91%***

Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering (Firm Level)	Yes	Yes	Yes	Yes	Yes	Yes
Observations (N)	40,245	84,135	26,377	36,294	61,810	22,266
R-squared	0.6823	0.8347	0.6225	0.6196	0.8030	0.6712
F-statistic	1275.16***	4228.77***	876.47***	1191.97***	2403.04***	857.46***

Note. Six institutional-life-cycle subsamples are reported. The AE Growth and AE Decline quadratic terms are not statistically significant; the 490.89-day AE Growth vertex also lies outside the observed CCC support (-100 to 365 days). Their reported turning points should therefore not be interpreted as statistically identified optima. Firm-clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4.4. Component Decompositions and Econometric Identification

4.4.1. Working Capital Component Decompositions

Table 9 decomposes CCC into inventory, receivables, and payables. The component evidence is less uniform than the aggregate CCC results. DSI is positive in the linear model but its quadratic terms are insignificant in the pooled quadratic and firm-fixed-effects specifications; only the dynamic model produces a statistically significant concave DSI profile. The inventory result is therefore estimator-sensitive rather than robustly nonlinear.

DSO shows a concave relation in the pooled quadratic and dynamic models, with reported vertices of 176.00 and 204.89 days, but the firm-fixed-effects model reverses the signs of the DSO terms. DPO is more stable: its linear coefficient is negative across specifications and its squared term is positive, yielding cash-minimizing points around 254–271 days. This pattern is consistent with payables providing cash substitution over much of the range, followed by curvature at very long payment cycles. Non-cash working capital remains strongly negative in all component models.

Table 9. Decomposed Working Capital Components: Inventory, Receivables, and Payables Cycles

Independent Variables	(1) Linear Components OLS	(2) Quadratic Components OLS	(3) Dynamic Components Partial Adj.	(4) Within-Firm FE Components
Days Sales of Inventory (DSI)	0.000034*** (0.000007)	0.000009 (0.000020)	0.000070*** (0.000006)	-0.000009 (0.000019)

DSI Squared (DSI² / 10⁴)		0.00091 (0.00054)	-0.00135*** (0.00018)	-0.00006 (0.00045)
Days Sales Outstanding (DSO)	0.000021* (0.000009)	0.000127*** (0.000023)	0.000075*** (0.000007)	-0.000128*** (0.000021)
DSO Squared (DSO² / 10⁴)		-0.00361*** (0.00067)	-0.00184*** (0.00023)	0.00179** (0.00056)
Days Payables Outstanding (DPO)	-0.000115*** (0.000010)	-0.000254*** (0.000024)	-0.000112*** (0.000008)	-0.000391*** (0.000019)
DPO Squared (DPO² / 10⁴)		0.00486*** (0.00070)	0.00221*** (0.00026)	0.00721*** (0.00051)
Lagged Cash Ratio (Cash_{t-1})			0.7756*** (0.0021)	
Non-Cash NWC / Assets	-0.1644*** (0.0034)	-0.1669*** (0.0035)	-0.0868*** (0.0014)	-0.1705*** (0.0031)
Controls (Size, Lev, ROA, Growth, CapEx)	Yes	Yes	Yes	Yes
Constant	0.2544*** (0.0042)	0.2549*** (0.0045)	0.0782*** (0.0016)	0.2786*** (0.0075)
Optimal DSO Turning Point		176.00 days***	204.89 days***	
Optimal DPO Turning Point		261.36 days***	253.85 days***	270.80 days***
Speed of Adjustment (SOA: lambda)			22.44%***	
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	No	No	Yes
Observations (N)	337,279	337,279	304,461	337,279
R-squared	0.1951	0.1959	0.6998	0.1223 (Within)
F-statistic	371.29***	341.05***	7515.78***	252.05***

Note. Decomposed working capital components: DSI, DSO, and DPO. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4.4.2. Advanced Econometric Identification and Endogeneity Suite

Table 10 assesses whether the baseline associations survive alternative timing and identification choices. Lagging the explanatory variables preserves the concave CCC relation and produces a turning point of 132.86 days, while lagged non-cash working capital remains strongly negative. The shift in the turning point relative to Table 4 again indicates that exact thresholds are model-dependent.

The peer-based 2SLS exercise has a very strong first stage (Kleibergen-Paap F = 2,794.53), but instrument strength does not establish the exclusion restriction. Moreover, the second-stage CCC coefficient is only marginally significant ($p = 0.088$) and the 2SLS column does not identify the quadratic CCC term. The IV results therefore do not confirm the baseline inverted-U shape, although they do preserve the negative relation between non-cash working capital and cash holdings.

The dynamic OLS column yields an implied turning point of 226.56 days and an SOA of 22.40%, but it remains subject to dynamic-panel concerns. The system-GMM column reports a 263.45-day vertex and 28.34% SOA, yet both AR(2) and Hansen tests reject at $p < 0.001$. Accordingly, Table 10 provides nuanced robustness evidence: the sign and nonlinearity of CCC survive several non-IV specifications, but the manuscript does not establish causal identification of the quadratic relation.

Table 10. Advanced Econometric Identification and Endogeneity Robustness Suite

Independent Variables	(1) Baseline OLS	(2) Lagged Controls (t-1)	(3) 2SLS IV Peers	(4) Dynamic Panel OLS	(5) Two-Step System GMM
Cash Conversion Cycle (CCC)	0.000093*** (0.000012)		0.000031 (0.000018)	0.000062*** (0.000004)	0.000104*** (0.000006)
CCC Squared ($CCC^2 / 10^4$)	-0.00254*** (0.00032)			-0.00136*** (0.00011)	-0.00197*** (0.00015)
Lagged CCC (CCC_{t-1})		0.000052*** (0.000013)			
Lagged CCC² (CCC²_{t-1} / 10⁴)		-0.00197*** (0.00033)			
Lagged Cash Ratio (Cash_{t-1})				0.7760*** (0.0021)	0.7166*** (0.0090)

Non-Cash NWC / Assets	-0.1525*** (0.0032)	-0.1183*** (0.0033) (t-1)	-0.1529*** (0.0055)	-0.0807*** (0.0013)	-0.1399*** (0.0020)
Controls (Size, Lev, ROA, Growth, CapEx)	Yes	Yes (t-1)	Yes	Yes	Yes
First-Stage Instrument			Peer CCC		L(2/3).Cash (Collapsed)
First-Stage Kleibergen-Paap F			2,794.53***		
Arellano-Bond AR(1) p-value					< 0.001
Arellano-Bond AR(2) p-value					< 0.001
Hansen J Overidentification p-value					< 0.001
Optimal CCC Turning Point	182.22 days***	132.86 days***		226.56 days***	263.45 days***
Speed of Adjustment (SOA: lambda)				22.40%***	28.34%***
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Clustering (Firm Level)	Yes	Yes	Yes	Yes	Yes
Observations (N)	354,625	319,820	354,621	319,398	319,398
R-squared / Wald Chi²	0.1902	0.1609	0.1892	0.6963	15,718.15*** (Chi²)

Note. Model 2 lags the explanatory variables by one year. Model 3 uses a leave-one-out industry-year peer CCC instrument (first-stage F = 2,794.53), but the second-stage CCC estimate is only marginally significant and the quadratic term is not instrumented/reported. Model 5 is two-step system GMM; AR(2) and Hansen p-values are both < 0.001, so the GMM specification fails key diagnostic tests and is not treated as confirmatory causal evidence. Firm-clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4.5. Discussion of Findings

The primary outcome is not a blanket CCC, but an alternative conditional liquidity trade-off. The cash/cash equivalent relation between the CCC and working capital is concave, while in the other principal static parameters, non-cash working capital is a strong cash equivalent. Whereas the location of the CCC vertex is a fundamental part of the fixed-effects structures, lags and subgroup models, however, it varies considerably. The estimated turning points are therefore to be regarded as sample specific indicators of the location of slope changes in the fitted relation and not as simple operating targets for managers.

The life-cycle evidence fits with previous research which identified that the amount of cash held and decision making on adjustment differs across life-cycle stages of an organisation (Rehman et al., 2021; Seidu et al., 2022). The most cash persistent firms are the mature firms and the fastest changing are the Introduction firms. This is in line with the notion that stable companies are more likely to be able to sustain longer cash shortfalls, while younger or weaker companies react faster to cash shortages.

Similarly, the institutional results also support evidence of country financial development and institutional quality being the main determinants of cash motives and adjustment dynamics (Das et al., 2022; Akhtar, 2023; Tran & Nguyen, 2025). The interaction term indicates that the rate of CCC growth is lower in Advanced Economies compared to EMDE firms, but the turning points for the separate samples and interaction differ. The economic implication is thus not a clear-cut, uniform difference between AE and EMDE “optimal” CCCs, but rather a liquidity architecture that is different.

The large negative coefficient on non-cash working capital is more useful to practitioners than any of the vertex estimates; in the absence of other controls, firms with greater operating liquidity have lower cash balances. The process of cash policy should be conducted in conjunction with other financial policies, such as receivables, inventory, payables, capital expenditure and leverage.

There are several caveats in interpreting the data. The sample does not include private or small firms and may not be representative; the bounds of CCC are not known but range from -100 to 365 days; cash-flow signatures are used to classify firms into their life-cycle; cash-flow signatures for certain subgroups may not be turning points; the peer-IV exclusion restriction cannot be verified from the reported tests; and the reported system-GMM specifications fail AR(2) and Hansen diagnostics. Alternative cash-target models, enhanced external instruments or quasi-experimental designs, and formal, cross-group tests of nonlinear turning points should be used in future work.

5. Conclusion and Policy Implications

5.1. Conclusion

This study examines the effects of working capital configuration on the level of cash holding and cash adjustment response of the firm for the different stages of the firm life cycle in the institutional environment. The analysis suggests that neither is there a universal cash target for corporate liquidity, using a large international sample of listed non-financial and non-utility companies from 134 economies between 2000 and 2025. Rather this reflects a conditional trade-off between the needs for financing operating cycle, inclusion of substitutes for internal liquidity, friction costs of adjustment, and the institutional context of the firms' operations.

The principal static evidence backs up a concave relationship between cash conversion cycle and cash holdings of the company. There is a relationship initially as long operating cycles lead to higher precautionary liquidity needs, but the relationship decreases once the expected turning point has been reached when working capital starts to become a stronger liquidity substitute. This explanation is supported by the negative relationship of non-cash net working capital with cash holdings, which is present in all periods.

The dynamic results also illustrate persistent and heterogenous cash adjustment. The adjustment process to target cash ratios takes place slowly over time; and the rate of adjustment differs for different stages of the firm's life cycle and institutional regimes. The intra-industry rebalancing process seems to take longer for mature firms, and more intense rebalancing pressures for introduction and decline firms, which are both consistent with the assumption that liquidity shortfalls are more costly in financially vulnerable stages. The shape of the CCC-cash relation and its economic meaning also depends on institutional differences: firms in the advanced economies and EMDE markets have different financing conditions.

5.2. Policy Implications

The results suggest that cash buffers should be managed in tandem with the firms' working-capital system, and not as a standalone treasury decision, for a manager or a board. In certain situations, a longer CCC does not necessarily mean higher cash balances because inventories, receivables or payables may bring an element of financing stress or may be part of the cash flow cushion for the operations. Boards should thus assess the cash objectives in conjunction with receivables collection policy, inventory control, supplier credit terms, leverage, capital expenditure and operating cash-flow fluctuations.

The evidence is stronger for the notion that, for companies at early or distressed life-cycle stages, a more aggressive approach to liquidity monitoring is warranted because a cash shortage may be more harmful due to adjustment costs and financing constraints. In the case of an established company, for which the internal cash flow is relatively stable, it may be efficient to adjust at a slower pace, but it can also be a symptom of inertia if cash balances shift from the need of the business. The results thus support stage-specific liquidity benchmarks, instead of a uniform rule of any CCC or cash-ratio.

The institutional evidence indicates that stronger financial infrastructure can diminish firms' need to maintain high levels of precautionary cash buffers, which are costly for policy makers and regulators. Better payment systems, better creditor protection, deeper credit markets and more efficient short-term credit markets can make working-capital management less cash-intensive, as external financing frictions are tighter in EMDE markets.

5.3. Limitations and Future Research Directions

There are some limitations which should be taken into consideration for interpretation. It may not be representative of small or private firms, or financially opaque firms. The meaning of the CCC measure is dependent on industry and is frequently restricted or modified by the economic characteristics of each sector, because of differing production cycles, customer credit terms and supplier-payment terms. The life cycle classification relies on the pattern of cash flows, and is informative, but it does not necessarily reflect a complete description of the strategic or organizational aspects of firm maturity.

It is also important to note that the econometric evidence should be interpreted as evidence of strong association and to be triangulated as robust evidence rather than as causal evidence. The turning points of some of the subgroups are sensitive to the estimator, and the dynamic GMM diagnostics suggest that some of the most provocative causal specifications should be viewed with the same modesty as cautioned against in the companion report. Going forward, it would be useful to use policy shocks, credit-supply shocks, payment-system reforms, supply-chain disruptions, or quasi-experimental designs to induce exogenous shocks to working-capital conditions to bolster identification.

Further research should examine the role of new digital payment technologies, supply-chain finance, ESG risk and macroeconomic uncertainty on changing the working capital/cash reserve substitution. Comparing listed and private companies is a potential next step, as is the inclusion of country-level legal and financial reforms more explicitly, and determining whether the CCC-cash turning point moves in crisis and recovery phases.

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