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Working Capital Behavior of Firms during an Economic Downturn: An Analysis of the Financial Crisis Era

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Abstract: In times of crisis, cash and liquidity play an essential role. This paper analyzes the working capital measures over the course of a business cycle. We examine (1) how companies behave in economic downturns regarding their working capital components and (2) whether firms with higher financial constraints behave differently in economic downturns regarding their working capital components. The analyses were conducted with descriptive statistics and generalized linear mixed-effects modeling. Our dataset consists of 2111 stock-listed firms and 10,555 observations spread over the period of five years during the financial crisis era. The findings indicate that days sales outstanding and shorter days inventory held are related to better financial performance while days payable outstanding had no observable effect. Furthermore, financially constrained firms have shorter days sales outstanding than average firms. In economic downturns, firms seem to reduce both working capital and fixed investments to asset ratios. The financially constrained firms pushed down their fixed investments ratio more aggressively than average firms while, in contrast, the financially strongest firms pushed down the working capital to asset ratio in comparison to average firms. Interestingly, neither the cash conversion cycle, days payable outstanding, nor company performance or fixed investments to asset ratios fully returned to the pre-shock level. The behavior of non-financially constrained firms, which also perform better, indicates a stronger supply chain orientation than that of average firms. This might indicate that the supply chain-oriented view of working capital management could provide a more favorable and resilient alternative to the prevailing self-orientation.

Keywords: supply chain financing; financial constraints; economic downturn; trade credit; insolvency risk; generalized linear mixed-effects model

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1. Introduction

The COVID-19 crisis in 2020 and 2021 massively distorted supply chains and resulted in one of the sharpest stock markets fall in history and a surprisingly fast recovery. This was followed in 2022 by the war in Ukraine and prolonged supply chain bottlenecks with skyrocketing energy prices and soaring inflation. Initially, the COVID-19 crisis appeared to be both supply and demand shocks, but the observed demand effects were mainly due to restrictions—not due to the willingness or ability to consume (Guerrieri et al. 2022). The central banks acted decisively and provided the market with ample liquidity, possibly contributing to the historically high asset price valuations (Borio 2020; Cantú et al. 2021; Echarte Fernández et al. 2021). However, in the second half of 2022, the world is entering unknown territory where central banks have limited room for liquidity boost, although the demand might start to decline (not least due to the increased interest rates). This means that collaborative working capital management might become an increasingly important source of financing. It follows that the supply chain should be seen as a means 'to fund' the

company. At the same time, due to the multiple interdependencies with suppliers, service providers and customers, the organization must also serve as a source for financing the supply chain (Rogers et al. 2020; Hofmann et al. 2021).

What is ahead might have some similarities (liquidity and demand shocks) with the economic downturn of 2009 (triggered primarily by the Lehman Brothers collapse in 2008), characterized by suddenly declining sales, putting a squeeze on revenues, profit margins and working capital requirements (Enqvist et al. 2014). During this crisis, the liquidity of many companies was under pressure and cash became a scarce resource due to the tight credit market conditions (Brunnermeier 2009). Chen et al. (2013) have documented that the internal liquidity risk along the supply chain affects a firm's credit risk, especially during the period of economic downturns. In addition, the internal liquidity risk covers the risk of working capital changes and the phenomenon of the "financial bullwhip effect" (Chen et al. 2013).

Supply chain management is seen as a possible competitive advantage (Green et al. 2006; Barney 2012; Helmuth et al. 2015). This topic is also valuable among practitioners and is underpinned by the increasing appointment of chief supply chain officers to top management teams (Roh et al. 2016). Overall, it is seen as a management philosophy highlighting interorganizational network aspects beyond the firm's boundaries (Mena et al. 2013). In contrast, reducing working capital is still suggested mainly with narrow single firm lenses resembling the classical self-orientation without considering the adverse effect on the adjacent supply chain members (Hofmann and Kotzab 2010). As a result, companies might optimize their financials without considering their affiliated suppliers and customers. Firms may have an optimal level of working capital that maximizes their single firm value (Bradley et al. 1984). However, adequate levels may differ to reflect changes in business conditions. Corporate executives can either strive to increase the firm's profitability, sometimes at the expense of supply chain partners, or seek to add value to their supply chain in the first place (Rogers et al. 2020). One argument is to minimize trade credit to reduce working capital, which correlates negatively with profitability (e.g., Deloof 2003; Lazaridis and Tryfonidis 2006; Charitou et al. 2010).

It is debatable whether firms should instead think more in terms of supply chains or if isolated and single-firm considerations are more beneficial to the shareholder value (Lanier et al. 2010; Wetzel and Hofmann 2019). The behavior of economically weak firms in terms of trade credit and inventory strategies in the supply chain might differ compared to financially strong firms. These differences are likely more distinct during economic downturns. Overall, financial constraints are widely acknowledged when discussing investment policies (Clementi and Hopenhayn 2006) but less so in studies of the relationship between working capital and firm performance (Baños-Caballero et al. 2014; Bode et al. 2014). Furthermore, it has been emphasized that to withstand liquidity constraints, managers adopt efficient working capital management policies during non-crisis periods to be prepared for a sudden economic downturn (Oseifuah 2018).

To address some of the remaining knowledge gaps regarding the working capital behavior of companies in times of an economic downturn, we refer to the following existing streams in literature: (i) The impact of firms' financial constraints on their investment policies—especially in times of a recession (e.g., Clementi and Hopenhayn 2006; Brunnermeier 2009; Baños-Caballero et al. 2014) and (ii) the relationship between working capital and firm performance (e.g., Deloof 2003; Enqvist et al. 2014; Lazaridis and Tryfonidis 2006). At this moment, we aim to make a contribution to (iii) supply chains as an alternative source of financing (e.g., Hofmann and Kotzab 2010; Huff and Rogers 2015; Wuttke et al. 2013; Rogers et al. 2020; Hofmann et al. 2021). Thus, the underlying research questions (RQs) of the study at hand are as follows:

RQ1: How do firms generally behave in economic downturns regarding their working capital components?

RQ2: Do firms with higher financial constraints behave differently in economic downturns regarding their working capital components than firms without financial constraints?

Our study aims to investigate these research questions through empirical work. Instead of determining specific hypotheses in the first place, it is much appreciated to understand the working capital behavior of firms during an adverse cash flow shock more thoroughly. Thus, we rely primarily on secondary data to address the research questions from a financial perspective, including working capital measures. We choose a historical perspective from the financial crisis era as we have a complete dataset around the crisis, and this crisis illustrates a demand and liquidity shock. The analyzed dataset consists of 2111 stock-listed firms and 10,555 observations spreading over the period of five years. The analyses were conducted with descriptive statistics and generalized linear mixed-effects modeling.

This article makes several contributions. First, by using a large secondary dataset, we combine the research of supply chain management and working capital management with firms' financial constraints and their investment policies. This expands the findings of Huff and Rogers (2015) and others in the trade credit (e.g., Daellenbach 1986; Lee and Rhee 2011) and supply chain financing literature (e.g., Wuttke et al. 2013; Hofmann and Zumsteg 2015).

Second, following the works of Enqvist et al. (2014) and Ramiah et al. (2014), we provide empirical evidence for working capital and its ability to buffer the negative effects during an adverse cash flow shock.

Third, we expand the theoretical lens of embeddedness in the supply chain (Kim and Henderson 2015) to the field of working capital management by showing that firms do not inevitably push their credit risk and capital cost towards upstream suppliers in times of an economic crisis.

Fourth, we found surprisingly strong support for supply chain-oriented behavior in working capital management, especially among better-performing firms. This observation has substantial implications for future research, as it is of particular interest to further study whether the supply chain-oriented mindset is truly spreading among the firms or whether the observed behavior results from some unknown dynamics.

Fifth, our findings should motivate practitioners to implement specific trade credit practices taking the different degrees of financial stability of their customers as well as suppliers into account. Instead of minimizing working capital from a single firm-based view, an adequate level of working capital inducing the financial health of the affiliated supply chain partners might also provide performance benefits to the focal firm.

Overall, our findings suggest that longer days sales outstanding and shorter days inventory held are related to better financial performance while days payable outstanding had no observable effect. Furthermore, financially constrained firms have shorter days sales outstanding than average firms. In economic downturns, firms seem to reduce both working capital and fixed investments to asset ratios. The financially constrained firms pushed down their fixed investments ratio more aggressively than average firms while, in contrast, the financially strongest firms pushed down working capital to asset ratio in comparison to average firms. Interestingly, neither the cash conversion cycle, days payable outstanding nor company performance or fixed investments to asset ratios fully returned to the pre-shock level. Perhaps surprisingly, the behavior of non-financially constrained firms, which also perform better, indicate stronger supply chain orientation than that of average firms during the economic downturn.

The article proceeds as follows: Section 2 delivers the theoretical background to the approach of this article. Section 3 develops the research propositions. Section 4 explains the methods applied. It encompasses the data sources, research variables as well as the statistical models and estimation. Section 5 includes the descriptive statistics and the estimation results. Section 6 discusses the findings and the limitations. Section 7 concludes the article.

2. Theoretical Backgrounds

One of the earliest sources of supply chain financing is Meltzer (1960), indicating that during periods of restricted money supply, liquid firms provide trade credit to increase the

sales to the less liquid business partners. Schwartz (1974) suggested an economic model with a rationale for the use of trade credit, acknowledged the differences in firms' access to external funds and noted that trade credit is offered more extensively in times of increased monetary constraints.

Despite the early observations, the impact of economic downturns on working capital management has received limited attention in research. Traditional working capital management practices are not necessarily sufficient during downturns (Simon et al. 2021). Furthermore, not many studies have investigated working capital management practices during a financial crisis regardless of the importance of working capital management in addressing liquidity shocks (Ramiah et al. 2014; Gonçalves et al. 2018).

As the focus of our study encompasses the working capital behavior in economic downturns, we refer to the credit crunch experienced resulting from the financial crisis to as a shock period. It is likely that the cost disadvantage of external finance compared to internal finance is relatively small before and after the shock period (Fazzari et al. 1988). This disadvantage is likely to rise heterogeneously during the shock period, causing more variability in investment policies. This is related to the differentiation between financially constrained and non-financially constrained firms and their access and availability of external finance, typically consisting of loans from financial intermediaries and debt issued on the capital market. According to Bernanke et al. (1996), the premium on external finance relates inversely to the firm's net worth.

Shin and Soenen (1998) provide an early analysis of the relationship between the net trade cycle and firm profitability, suggesting a strong negative relationship between a firm's net trade cycle and profitability. Furthermore, stock returns indicate a negative correlation with the level of working capital. Thus, reducing working capital appears to increase shareholder value (Brandenburg 2016). Later, this is further complicated by the suggestion that the cash conversion cycle has a negative relationship with the firm's profitability and value, but the effect reduces or reverses at the lower level of the cash conversion cycle (Chong-Chuo 2018). In addition, the cash conversion cycle is observed to have a negative impact and governance quality (Vu Thi and Phung 2021).

In this context, the presented financial figures play a role in measuring the firm's performance from an interorganizational perspective. According to Farris and Hutchinson (2002), the indicators are composite metrics to assess operational excellence through cash flow management as well as the capabilities to manage the capital more efficiently as part of a supply chain. Derived from published financial reports and under consideration of the specific industry, the working capital measures (i.e., the cash conversion cycle or cash-to-cash cycle) also illustrate the dynamics of a business by combining inbound material activities with suppliers, through manufacturing operations, and outbound sales activities (Lind et al. 2012). Fazzari et al. (1988) argue that in order to allow steady investments, when the cost disadvantage of external finance over internal funds increases, a high dividend-paying firm can retain its income to substitute external funds. On the other hand, firms that retained a larger portion of their income have limited alternative sources of financing resulting in an investment policy that is sensitive to changes in the cost of external capital.

Although there are explicit accounting distinctions, working capital and fixed assets are considered to be part of operating capital. As aforementioned, the main distinction lies within the liquidity of the two components. Defined as the difference between a firm's current assets and current liabilities, it can be shown that working capital competes with fixed assets for a limited pool of finance (Fazzari and Petersen 1993). Contrary to current assets, fixed assets are not meant to be liquidated within one year (Ding et al. 2013). Accordingly, it is costly for firms to change the level of these investments in the short term. Especially for financially constrained firms, it would be much more appreciated to bounce back from cash flow shocks on fixed investments first by adjusting working capital (Fazzari and Petersen 1993).

Despite the well-known benefits of SCM in operations, only a few firms recognize the potential of interorganizational networks for their financial practices through collaboration

(Simatupang and Sridharan 2005). It seems to be necessary to develop an improved understanding of financial performance management in networks from a more holistic supply chain perspective (Busi and Bititci 2006). Following D'Avanzo et al. (2003), successful supply chain management correlates highly with the financial performance of the firm. Subsequently, supply chain leaders show significantly above-average financial performance (Greer and Theuri 2012). Referring to an interorganizational scale, it must also be stated that single supply chain members often act against the supply chain surplus when achieving the same goal of improvement (Hofmann and Kotzab 2010). Financial factors, such as credit risk and capital costs are often transferred toward the upstream supply chain (Rafuse 1996). Although extended payment terms constitute a lower risk to the buyer, they can destabilize the entire supply chain as a result of a higher-risk supplier base and their restricted access to short-term financing (Seifert et al. 2013). Referring to Huff and Rogers (2015), research has been extended on supply chain finance strategies and their effects on firm performance, analyzing working capital metrics over time.

Research on working capital management has focused mainly on measures and dynamics from a single firm perspective, whereas investigations within the supply chain context have shown deficits in financial aspects and managerial accounting support (Viskari and Kärri 2012). Only a few analyses are based primarily on "partnership financing" (Akhtar 1997), "cooperative finance" (Van Sickle and Ladd 1983) or "supply chain finance-oriented working capital management" (Wetzel and Hofmann 2019). While it is assumed that most firms operate with a certain level of working capital, the single firm tries to have less capital tied-up in non-productive stocks, shortens the time for accounts receivables and extends cash payments for accounts payable as far as possible (Farris and Hutchinson 2002). On this basis, Hofmann and Kotzab (2010) further examined a supply chain-oriented approach to working capital management through the cash conversion cycle. In distinction to the traditional cash conversion cycle objectives, an adequate collaborative cycle is one that minimizes the cost of tied-up capital while maximizing the gains of cash received across the participating supply chain members. From an interorganizational perspective, firms with lower refinancing rates and greater financial strength should carry more working capital compared to firms with higher financing costs. Grosse-Ruyken et al. (2011) present a similar argument, suggesting to consider up- and downstream partners and that an adequate level of working capital depends, among others, on the business model, specific design configurations and risk aspects within the supply chain.

3. Research Propositions

The absorption of an adverse cash flow shock is related to the adjustment costs of fixed investments and working capital (e.g., Fazzari and Petersen 1993; Carpenter et al. 1994; Ding et al. 2013). Typically, the adjustment costs for fixed investments are higher than that for working capital (Carpenter et al. 1994). As fixed investments are not as liquid as working capital components, their "fire-sale price" is lower. Furthermore, these decisions also affect the supply chain. Thus, the priorities of investments have also a signaling effect such that working capital investments signal supply chain considerations and fixed assets focus more on self-orientation. Based on this reasoning, we put forth our first Proposition 1:

Proposition 1. *In economic downturns, firms generally try to reduce their working capital components rather than their fixed assets.*

As the balance sheets of financially constrained and non-constrained firms typically differ, it is likely that they also have different adjustment costs allowing us to study the differences in fund allocation once a cash flow shock occurs. Non-constrained firms should find it easier to reduce working capital than constrained firms (Fazzari and Petersen 1993). Constrained firms are not in a favorable position to lower their working capital without endangering the operational business. Due to the higher stock and the lower adjustment cost of working capital, non-constrained firms might be able to buffer an adverse cash

flow shock to a large degree with working capital and hold fixed investments relatively stable (Carpenter et al. 1994). Constrained firms, in contrast, are more likely to reduce fixed investments instead of working capital, as further reduction could seriously endanger their operational readiness up to the risk of insolvency. Thus, our second Proposition 2 encompasses the following:

Proposition 2. *In economic downturns, financially strong firms cope with an accompanying liquidity shock via noticeable adjustments to their working capital, whereas financially constrained firms show limited behavior.*

4. Methods

4.1. Sample

The annual corporate data from firms listed in the USA, Europe, and Japan were retrieved from the Thomson ONE database. Firms from developed credit markets were selected as the financial constraints should be imposed by a credit crunch instead of structural underdevelopment. Following the approach of Bastos and Pindado (2007), the selection criterion was that firms should have a natural composition of working capital that includes inventories. The industries included are given in Appendix A. All firms were required to be stock exchange listed because one key variable in the analyses is Tobin's Q, i.e., the ratio between a physical asset's market value and its replacement value (Brainard and Tobin 1968).

The dataset consists of relatively large, well-established firms as firms were chosen based on the stock listing, the region, industry classification and were required to have data from all study years allowing balanced research design. Observations including negative values for assets and observations with missing values were omitted. After these removals, the final dataset consisted of 2111 firms and 10,555 observations spreading over the period from 2007 to 2011. The dataset had some very large or small values that were clearly errors. However, because of the size of the data, it is not possible to check all observations individually. For the reported analyses, outliers were omitted from the dataset by excluding 1% of observations from both tails of each variable. It needs to be noted that the conclusions are not sensitive to the exact cut-off point. Values in local currencies (EUR and JPY) were converted to USD with the end of the year exchange rate stated by the Fed (Federal Reserve 2014). The data are biased towards the USA with 5820 measurements, while the number of measurements from Japan (2715) and Europe (2020) were less than half of that.

In addition to firm-specific data, macroeconomic data were extracted to check how the shock affected different industries and sectors in different regions. For this purpose, historical data of industrial production were obtained for the period of 2000–2015. The data for the industrial production of the European Union were obtained from Eurostat (European Commission 2015), for the industrial production of Japan from the Ministry of Economy, Trade and Industry Japan (METI 2015), and the corresponding data for the USA were obtained from the Federal Reserve (2015).

4.2. Research Variables

By definition, the economy may be considered to be in a state of decline when the gross domestic product has declined for two consecutive quarters. Following this idea, the shock year was defined by identifying the time point when the industrial production in each industry within each region had declined for two quarters. Thus, the dataset was grouped into the non-shock and shock periods first industry and region wise. However, it was found out that several industries behaved similarly, following a pattern where sectors closer to the manufacturing of capital goods reacted more rapidly and more severely and sectors producing goods for the consumer markets reacted either more modestly or not at all to the crisis. Thus, it appeared that the industry level classification was too detailed and further grouping of the industries made sense. For this reason, the industries were grouped following the Global Industry Classification Standard (GICS) by MSCI and S&P.

GICS is an industry classification standard, which consists of 10 sectors, 24 industry groups, 67 industries, and 156 sub-industries. For this research, the industries were grouped into the sector level of GICS classification. The sectors included in the analysis are presented in Appendix A. Some sectors seem to be quite unaffected by the shock. Eventually, it also turned out that on a yearly aggregate level, the shock year can be identified as 2009 in all the included regions and sectors if they were affected.

According to Lind et al. (2012), working capital (*WC*) can be defined as current assets minus current liabilities. Fixed investments (*FI*) are the second group of assets and are not planned to be liquidated within one year (fixed assets and long-term investments). The ratios of days sales outstanding (*DSO*), days inventory held (*DIH*), and days payable outstanding (*DPO*) are the main representatives of working capital. Together, they form the cash conversion cycle (*CCC*) introduced by Richards and Laughlin (1980).

The fluctuations in investments made during the times of higher cash flows compared to investments during the times of lower cash flows can be used as a proxy for financial constraints. According to Ding et al. (2013), higher sensitivities imply higher financial constraints. For each firm i the firm-level fixed investment sensitivity (*FIS*), and thus financial constraint, is calculated as follows:

$$FIS_i = \sum_{t=1}^{n} \left(\frac{(CF/A)_{it}}{\sum_{t=1}^{n} (CF/A)_{it}} \left(\frac{FI}{A} \right)_{it} \right) - \frac{1}{n} \sum_{t=1}^{n} \left(\frac{FI}{A} \right)_{it} \quad (1)$$

where *CF* is the cash flow, *A* stands for the total assets at the beginning of the period, *FI* is the fixed investments and t denotes the time period. The higher the value is, the closer the investments track the cash flows, i.e., higher investments during the years of high cash flows and lower investments in the years of low cash flows. An adverse cash flow shock should affect fixed investments of financially constrained firms more severely (Bernanke et al. 1996). In this article, following the idea of Hovakimian and Hovakimian (2009), firms were first sorted in ascending order by *FIS* and then divided into three groups such that the least financially constrained firms are up to the first 15% (Low_{Fis}), highly constrained firms are above the 85% ($High_{FIS}$) and the remaining firms between 15% and 85% are averagely constrained ($Base_{FIS}$). These averagely constrained firms were used as a reference category. The lower limit was set further than proposed by Ding et al. (2013) as the dataset is limited to stock-exchange-listed entities that are on average potentially less financially constrained than an average firm if all firms were included. It needs to be noted that there are alternative ways to measure financial constraints such as dividend payout plan (Fazzari et al. 1988; Fazzari and Petersen 1993). Carpenter et al. (1994) utilized firm size and an alternative grouping based on the firms' bond ratings. Bernanke et al. (1996) considered size as a proxy for access to the credit market. Research variables are summarized in Table 1.

Table 1. Summary of research variables.

Research Variable	Definition
Tobin's *Q* (*Q*)	The ratio between the book value and the market value (logarithmically transformed in the analysis).
FI	Fixed investments.
A	The total assets at the beginning of the period.
CF	The cash flow.
Fixed investment sensitivity (*FIS*)	$FIS_i = \sum_{t=1}^{n} \left(\frac{(CF/A)_{it}}{\sum_{t=1}^{n} (CF/A)_{it}} \left(\frac{FI}{A} \right)_{it} \right) - \frac{1}{n} \sum_{t=1}^{n} \left(\frac{FI}{A} \right)_{it}$
Financially constrained firm ($High_{FIS}$)	Financially constrained firms are above 85% of *FIS* (i.e., high value of *FIS*).
Non-financially constrained firm (Low_{Fis})	Non-financially constrained firms are up to the first 15% of firms (i.e., low value of *FIS*).

Table 1. *Cont.*

Research Variable	Definition
Averagely financially constrained firm ($Base_{FIS}$)	Firms between 15% and 85% of fixed investment sensitivity (*FIS*) are used as the reference group in the analysis.
Days sales outstanding (*DSO*)	$DSO = \left(\frac{AccountsReceivable}{Sales}\right)365$
Days inventory held (*DIH*)	$DIH = \left(\frac{Inventory}{Sales}\right)365$
Days payable outstanding (*DPO*)	$DPO = \left(\frac{AccountsPayable}{Sales}\right)365$
Cash conversion cycle (*CCC*)	$CCC = DSO - DIH - DPO$
Shock year (*T*)	T = 1 when the industrial production had declined for two consecutive quarters in the firm sector during the year otherwise (T = 0). Turned out to always be the year 2009.
Ratio of cash flow from financing to the total assets at the beginning of the period (*CFFintoA*)	$CFFintoA = \frac{CFFin}{A}$, where *CFFin* stands for cash flow from financing.
Ratio of working capital to the total assets at the beginning of the period (*WCtoA*)	$WCtoA = \frac{WC}{A}$, where *WC* stands for working capital and A the total assets at the beginning of the period.
Ratio of investments to the total assets at the beginning of the period (*ItoA*)	$ItoA = \frac{FI}{A}$, where *FI* represents fixed investments.

4.3. Statistical Models and Estimation

The dataset analyzed in this article is a panel data consisting of several measurements from each firm. Furthermore, the sectors and regions are of importance. This necessitates the use of a mixed-effects model that has fixed-effects and random-effects terms. Fixed-effects terms are the conventional linear regression part and random-effects terms are associated with individual experimental units drawn at random from a population, and account for variations between the groups. Moreover, prior to the analysis, the research variables were tested for normality and most of the dependent variables were found to be skewed and non-normal. Because of the non-normality of the measures, generalized linear mixed-effects models (GLMEs) were employed. GLMEs are a generalization of linear mixed-effects models (LME) when the response variable is not normally distributed and they allow the modeling of the relationship between a response variable and independent variables using coefficients that can vary with respect to grouping variables. Following Engblom et al. (2012), a general matrix form of a linear mixed model is defined as

$$\mathrm{Y} = \mathrm{X}\beta + \mathrm{Z}\mathrm{b} + \epsilon \tag{2}$$

where Y is a matrix for dependent variables and X and β are for fixed effects. Linear dependency is assumed through a link function, which in this illustrative case is identity. Z is a known design or incidence matrix for the random effects, and b is a vector that contains the coefficients of the random variables. Matrix ε represents the residuals of the model. If matrices b and ε are normally distributed

$$\begin{pmatrix} \mathrm{b} \\ \varepsilon \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \mathrm{D} & 0 \\ 0 & \Sigma \end{pmatrix}\right) \tag{3}$$

then D and Σ are covariance matrices of b and ε. This also implies that b and ε are independent (Duchateau and Janssen 1997). Coefficients in b are subject-specific (Molenberghs and Verbeke 2005). Subjects may contain groups of measurements from the same observation or groups of observations. Group means can be estimated using parameter estimates for

categorical independent variables or interaction effects. A specific covariance structure is also assumed for D and Σ, which contain covariances of random effects and residuals of the model.

In many cases, linear dependency is assumed through link functions other than identity. Here,

$$\mathrm{Y} = \mu + \varepsilon \tag{4}$$

encompasses

$$\mathrm{g}(\mu) = \mathrm{X}\beta + \mathrm{Zb}. \tag{5}$$

when Y is assumed to be gamma-distributed, a logarithmic link function g(μ) = $ln(\mu)$ is usually used, as in this case. If (3) and (4) are combined with the logarithmic link function, the GLMM becomes

$$\mathrm{Y} = \mathrm{g}^{-1}(\mathrm{X}\beta + \mathrm{Zb}) + \varepsilon = e^{\mathrm{X}\beta + \mathrm{Zb}} + \varepsilon. \tag{6}$$

In this article, the estimation started from full model (starting model) with all potential independent variables included. Then, the final models were derived through stepwise procedure with backward elimination where the candidates were removed one by one from the models, based on the *p*-value until only significant variables ($p < 0.1$) were left in the final model, except if the interaction term was significant but the main effect was not. In these cases, the main effect was left in the model.

In this article, reported models have either Gamma distribution and logarithmic link function (Equation (7)) or normal distribution and identity link (Equations (8)–(10)). The starting models were as follows:

$$\begin{Bmatrix} DPO \\ DSO \\ DIH \\ ItoA \end{Bmatrix} = \mathrm{Exp}\begin{pmatrix} \alpha + \beta_1 Time + \beta_2 T + \beta_3 High_{FIS} + \beta_4 Low_{Fis} + \\ \beta_5 High_{FIS} * T + \beta_6 Low_{Fis} * T + \\ \beta_7 CFFIntoA + \beta_8 Log(Q) + \\ b_i + c_j + d_h \end{pmatrix} + \varepsilon_{ij} \tag{7}$$

and

$$\begin{Bmatrix} CCC \\ WCtoA \end{Bmatrix} = \begin{matrix} \alpha + \beta_1 Time + \beta_2 T + \beta_3 High_{FIS} + \beta_4 Low_{Fis} + \\ \beta_5 High_{FIS} * T + \beta_6 Low_{Fis} * T + \\ \beta_7 CFFIntoA + \beta_8 Log(Q) + \\ b_i + c_j + d_h \end{matrix} + \varepsilon_{ij} \tag{8}$$

and

$$Log(Q) = \begin{matrix} \alpha + \beta_1 Time + \beta_2 T + \beta_3 High_{FIS} + \beta_4 Low_{Fis} + \\ \beta_5 High_{FIS} * T + \beta_6 Low_{Fis} * T + \\ \beta_7 CFFIntoA + \\ b_i + c_j + d_h \end{matrix} + \varepsilon_{ij} \tag{9}$$

and

$$Log(Q) = \begin{matrix} \alpha + \beta_1 Time + \beta_2 T + \beta_3 High_{FIS} + \beta_4 Low_{Fis} + \\ \beta_9 DPO + \beta_{10} DSO + \beta_{11} DIH + \\ b_i + c_j + d_h \end{matrix} + \varepsilon_{ij} \tag{10}$$

where the dependent variables are: *CCC* is the cash conversion cycle, *DPO* is the days payable outstanding, *DSO* is the days sales outstanding, *DIH* is the days inventory held, *WCtoA* is the ratio of working capital to the total assets at the beginning of the period *A*, *ItoA* is the ratio of fixed investments to the total assets at the beginning of the period and *Q* is the Tobin's *Q*.

For the fixed effects, *Time* is the year (2007 = 1, 2008 = 2, . . . , 2011 = 5), *T* is a dummy for a shock year, $High_{FIS}$ is a dummy for financially constrained firms, Low_{FIS} is a dummy for the least financially constrained firms (average firms are the reference category), $High_{FIS}$*T and Low_{FIS}*T are the interaction terms whose coefficients β_5 and β_6 capture the effect if the most and the least financially constrained firms reacted differently to the shock compared to average firms, Log(*Q*) is the logarithm of Tobin's *Q* and *CFFIntoA* is referring to the ratio

of cash flow from financing to capital. To control for heteroscedasticity, WC and CFFin are scaled by A. In (9), the coefficients β_9, β_{10} and β_{11} indicate the influence of *DSO*, *DIH* and *DPO* on firm performance.

Concerning the random effects, the intercepts for individual firms, industries and regions were assumed to be random in the models, and therefore the coefficients b_i, c_j and d_h were included, meaning that every firm, sector and region was assumed to have its own baseline level for the dependent variable. A model with a random slope for each firm and a model where the industry was assigned a random intercept instead of the sector were also tested but these models were always much worse than the reported model based on Schwarz information criteria.

5. Analysis and Results

5.1. Descriptive Results

Descriptive statistics on the research variables reveal interesting differences. Table 2 shows the medians of sales, accounts receivable, accounts payable and inventory. Based on median sales, Japanese firms are the largest and European firms are the smallest. The smallest median sales year is either 2010 (Japan) or 2009 (EU and USA). Perhaps surprisingly, US firms have the largest median inventory and the smallest amount of accounts payable every year.

Table 2. Median of sales, accounts receivable and accounts payable in Japan, EU and US between 2007 and 2011 (in millions of dollars).

	Sales			Accounts Receivable			Accounts Payable			Inventory		
Year	**Japan**	**EU**	**US**	**Japan**	**EU**	**US**	**Japan**	**EU**	**US**	**Japan**	**EU**	**US**
2007	351	295	336	99	72	63	63	38	28	39	47	51
2008	460	307	369	119	77	62	78	44	25	50	48	56
2009	403	284	291	90	74	56	54	42	23	44	45	49
2010	396	290	323	104	77	64	65	45	28	41	47	52
2011	458	324	381	117	73	70	71	42	29	46	52	65

Table 3 lists the Tobin's *Q*, *DSO*, *DIH* and *DPO* in Japan, EU and USA between 2007 and 2011. The Tobin's Q in the US is the highest during the entire observation period, with the EU following next and Japan having the lowest Q. For example, the Tobin's *Q* is 1.20 in the USA in 2007, whereas the corresponding figures of EU and Japan are 0.87 and 0.57. Another observation about the Tobin's *Q* is that different regions have the low point of the Q in different years. While US and EU firms have the lowest *Q* in 2008, the low point in Japan is a year later, in 2009. In addition, the Tobin's *Q* of the US firms recovers rather quickly, even though it does not reach the pre-shock levels during the observation period. At the same time, the Tobin's *Q* of the EU firms remains at a low level after the crisis in 2009.

Table 3. Median of Tobin's Q, days sales outstanding (*DSO*), days inventory held (*DIH*) and days payable outstanding (*DPO*) in Japan, EU and US between 2007 and 2011.

	Tobin's Q			DSO (Days)			DIH (Days)			DPO (Days)		
Year	**Japan**	**EU**	**US**	**Japan**	**EU**	**US**	**Japan**	**EU**	**US**	**Japan**	**EU**	**US**
2007	0.57	0.87	1.20	102	90	58	46	53	45	60	49	29
2008	0.42	0.52	0.79	95	83	50	46	54	45	56	47	26
2009	0.36	0.61	0.92	82	84	56	48	53	46	44	44	27
2010	0.44	0.65	1.04	99	85	57	46	58	46	53	47	30
2011	0.43	0.56	0.93	97	80	55	45	56	46	53	45	28

As with the Tobin's Q, there are also differences between the regions in the payment times, the *DSO* and *DPO* and the *DIH* between the regions. It seems that both the *DSO* and *DPO* of the Japanese firms are systematically higher (102 and 60 days in 2007) than those of the European and US firms. Similarly, the *DSO* and *DPO* of the US firms are the lowest during the entire observation periods.

The differences in days of inventory held are smaller. The *DIH* of Japanese firms varies between 45 days in 2011 and 48 days in 2009, whereas the corresponding numbers for EU and USA are 53 and 58 days for EU firms and 45 and 46 days for the US firms.

Table 4 summarizes the differences between the financially constrained ($High_{FIS}$) and non-financially constrained firms (Low_{FIS}) as well as the reference group ($Base_{FIS}$). The Tobin's *Q* of firms with low or high financial constraint as well as of the reference group declines rapidly in 2008, where after it recovers in 2009 and 2010, only to decline again in 2011. Both the days of sales and days of payable outstanding decline in 2008 and recover slightly in 2009, without reaching the pre-shock levels after that. The days inventory held, on the other hand, remains stable during the entire observation period. With all the mentioned variables, it seems that both the low and high *FIS* firms have shorter *DSO* and *DPO* and less *DIH* than the reference group.

Table 4. Median of Tobin's Q, days sales outstanding (*DSO*), days inventory held (*DIH*) and days payable outstanding (*DPO*) in low (Low_{FIS}), high ($High_{FIS}$) and base ($Base_{FIS}$) groups of financially constrained firms. Financially constrained firms have high values of fixed investment sensitivity (FIS), non-financially constrained firms have low values of FIS and average firms are used as a reference group base.

	Tobin's Q			DSO (Dayss)			DIH (Days)			DPO (Days)		
Year	**$Base_{FIS}$**	**Low_{FIS}**	**$High_{FIS}$**	**$Base_{FIS}$**	**Low_{FIS}**	**$High_{FIS}$**	**$Base_{FIS}$**	**Low_{FIS}**	**$High_{FIS}$**	**$Base_{FIS}$**	**Low_{FIS}**	**$High_{FIS}$**
2007	0.91	1.11	1.02	75	68	68	47	48	43	40	37	37
2008	0.61	0.71	0.64	68	62	58	48	45	45	37	33	34
2009	0.67	0.78	0.74	69	66	59	48	45	45	35	32	34
2010	0.76	0.90	0.80	71	68	66	49	48	43	39	37	39
2011	0.69	0.84	0.75	70	62	65	48	45	46	38	34	35

5.2. Model-Based Results

The model-based results from fixed effects are presented in Table 5. The sector and region were included in the model as random effects and are not elaborated as their effects cannot be generalized. The existence of random effects, logarithmic link function, interaction terms and the transformations cause the values of coefficients to be relatively difficult to interpret. Significant coefficients were only included into the final models except when the interaction term was significant but some of the main effects were not. In these cases, the main effect(s) were also included. The main effects should not be interpreted when there is an interaction term in the model. As the signs and significance of the main effects remain the same when interactions are removed, no separate table is included for the interpretation of main effects.

It seems that the cash conversion cycle increased slightly over time and that it increased more notably during the shock. Within the sample, the financially constrained firms ($High_{FIS}$) seem to have shorter cash to cash conversion cycles than the average firms. Strong cash flow from financing to the total assets at the beginning of the period seems to result in longer *CCC* and the Tobin's Q seem to have no effect.

The shock also seems to affect all of the components of the cash conversion cycle. This reveals interesting dynamics about how firms absorb the effects of a shock. The shock pushes up the inventories but at the same time *DSO* decreases. Furthermore, *DPO* decreases, meaning that firms pay their suppliers faster. However, this could also be partly because firms might temporarily buy less. Overall, *DPO* seems to have a slight decreasing trend. Perhaps more surprisingly, firms with different financial constraints react similarly

to the shock in terms of *DPO* and *DIH*, but the least financially constrained firms—the financially strongest—tend to reduce *DPO* less than average firms, perhaps allowing time for their supply chain partners to adjust to the shock. It should also be noted that in total the most financially constrained firms have shorter *DSO* than average firms.

Table 5. Model-based results (models 7 to 9). The starting model, applied link function and distributions are shown. The coefficients for fixed effects shown are from the final models that include only the significant coefficients except when the interaction term was significant but some of the main effects were not. In these cases, the main effect(s) are also included and shown. The sector and region were included in the model as random effects that cannot be generalized (coefficients not shown). The fixed effect coefficient values have no simple interpretation because of the existence of random effects, logarithmic link function in most cases, interaction terms and the applied transformations. The main effects should not be interpreted when there is an interaction term in the model. However, in our case, the signs and significance of the main effects remain the same if interactions are removed.

		Dependent Variables						
		CCC	**DSO**	**DPO**	**DIH**	**WCtoA**	**ItoA**	**Log(Q)**
Starting model		8	7	7	7	8	7	9
Distribution		Normal	Gamma	Gamma	Gamma	Normal	Gamma	Normal
Link		Identity	Log	Log	Log	Identity	Log	Identity
Intercept		0.77 **		−0.69 **	−1.2 **	0.18 *	−0.63 **	
	Time	0.0064 **		−0.0074 **			−0.0049 **	−0.030 **
	T (Shock)	0.041 **	−0.023 **	−0.093 **	0.040 **	−0.027 **	−0.093 **	−0.13 **
	FIS Low	(0.034)	(0.013)			(−0.039)	(0.051)	0.038 *
Independents	FIS High	−0.063 **	−0.12 **			−0.10 **	(0.013)	(0.016)
(fixed effects)	T*LowFIS		0.065 **			−0.035 **	(−0.024)	
	T*HighFIS		(−0.0029)			(−0.010)	−0.053 **	
	Log(Q)		0.079 **	0.050 **		0.053 **	0.056 **	N.a.
	CFFintoK	0.0014 **	0.0034 **	0.0043 **	0.0029 **	0.00099 **	0.0067 **	0.0023 **

* $p < 0.1$, ** $p < 0.01$, () not significant. Not shown = not in the final model. N.a. not included in the starting model. For the analyses, all values of *CCC*, *DSO*, *DPO* and *DIH* were divided by 100.

All these findings combined, it seems that the shock causes the inventory levels (*DIH*) to increase and accounts payable (*DPO*) to decrease, which causes the firms to react by adjusting *DSO*. As the total *CCC* increases, the results imply that the effects of increasing inventory cannot be fully offset by the changes in payment times. Considering the financial constraint, it seems that the effect is especially on the *DSO*, where the firms seem to be different.

The ratios related to capital behave differently in the analysis. Overall, the ratio of working capital to the total assets at the beginning of the period remains about the same level over time, while the trend for the ratio of investments to the total assets at the beginning of the period declines slightly. The shock is pushing both ratios down. The effects of financial constraint are also different. *WCtoA* is smaller for the most financially constrained firms but the financially strongest firms reduce *WCtoA* more than average firms during the shock. On the other hand, the most constrained firms seem to reduce *ItoA* more due to the shock than average firms.

Tobin's Q, indicating the financial performance of firms, decreases slightly overtime and the shock has quite a strong negative effect on it. Unsurprisingly, the non-financially constrained firms perform better than average firms. Table 6 show the results based on model 10 that further elaborates the interplay between the working capital component and the financial performance. These findings further support the earlier findings: there is a slightly negative trend, the shock had a negative effect, financially strong firms perform better, longer *DSO* and smaller *DIH* result in better performance and *DPO* has no effect.

Table 6. Model-based results from the model 10 which had normal distribution and identity link. The coefficients for fixed effects shown are for the final model that only includes significant coefficients. The sector and region were included as random effects that cannot be generalized (coefficients not shown). It appears that there is a slight negative trend, the shock had a negative effect, financially strong firms perform better, longer *DSO* and smaller *DIH* result in better performance and *DPO* has no effect.

		Independents (Fixed Effects)							
Dependent	**Starting Model**	**Time**	**T (Shock)**	**Low_{FIS}**	**$High_{FIS}$**	**DPO**	**DSO**	**DIH**	**CFFintoA**
Log(Q)	10	−0.032 **	−0.14 **	+0.074 *	(−0.013)		+0.12 **	−0.093 **	+0.0011 *

* $p < 0.1$, ** $p < 0.01$, () not significant, not shown = not in the final model. Note: this model had normal distribution and identity link.

6. Discussion

6.1. Relationship between Working Capital, Operating Assets and Firm Performance

Concerning the first research question, RQ1, we examine the general behavior of the supply chain members and their financial performance from a working capital perspective during a shock period. We further set forth the proposition that in economic downturns, firms generally try to reduce their working capital components rather than their fixed assets. The findings show that the shock period indeed had an immediate impact on all variables relating to the firm performance.

Overall, it seems that the cash conversion cycle increased mainly due to increased DIH. This "prolongation effect" was also observed in other studies during the COVID-19 crisis (Tarkom 2022). Thus, firms could not fully mitigate this effect by adjusting payment terms and purchasing less. Overall, both DSO and DPO became shorter during the shock. As we also observed a slight increasing trend in CCC, it might be that firms were not fully able to resume pre-shock inventory and payment policies after the shock. In particular, the DSO shows a decreasing trend indicating that firms collect money slightly faster after the shock than before it. In practice, such a *DSO* reduction is usually interpreted as stabilizing after a crisis, as shown by the analyses of data provider Dun & Bradstreet[1]. After all, such a reduction in DSO should increase firm performance similar to a reduction in DIH but with even a higher magnitude (Lind et al. 2012). Although DPO could be stretched to deliver higher financial performance, it also decreases. Even though we conclude that firms do not push their credit risk and capital cost towards upstream suppliers in times of an economic crisis, it is also likely that firms just decline purchasing activities to stabilize their corporate finance. All in all, the effect of a shock on cash conversion cycle is several magnitudes more significant than the changes over time.

Tobin's Q, defined as the ratio of market value to the book value of a firm's assets, indicates strong dependency. As expected, the shock caused Tobin's Q to decline and, as in the case of the cash conversion cycle, the negative trend over time indicates that the performance did not fully return to the pre-shock level. Longer *DSO* and smaller *DIH* result in better performance, as are expected. Furthermore, strong cash flow from financing to the total assets at the beginning of the period seems to increase the values of all performance metrics. This result is also consistent with the findings from the recent COVID-19 crisis, as Zheng's (2022) analysis shows that the effect of cash holdings helps mitigate the adverse impact of the overall market.

Referring to our first proposition PP1, we suppose that working capital plays a substantial role in buffering the effects during an adverse cash flow shock. On one hand, although the cash conversion cycle goes up due to the crises, on the other hand, both the working capital and fixed investments to the total assets at the beginning of the period go down. Thus, there is no clear evidence for reducing working capital to stabilize fixed assets, as both operating capital components are negatively affected by the shock. Following a fixed investment smoothing strategy, firms typically tend to decrease their working capital components rather than their fixed assets. However, our results show that firms react to in-

creasingly imposed financial constraints and limited access to external funds by liquidating operating assets. According to Fazzari and Petersen (1993), who imply lower adjustment costs for working capital compared to fixed investments, the behavior could be interpreted as a "rash decision" of firms in the face of an uncertain crisis. Possibly, there could also have been a "copycat effect" here, such as that found by Rind et al. (2021) in their recent study on trade credit decisions. First companies have started doing this, followed by a mimicking behavior of other market participants.

6.2. Impact of Firms' Financial Constraints on Investment Policies and Working Capital Management

We elaborated on the second research question, RQ2, to obtain evidence about the behavior of firms with higher financing and non-constraints regarding their working capital metrics, fixed assets and investment policies compared to average firms. Overall, analyzing the firms' capabilities to manage their capital, we observe significantly shorter *CCC* and *DSO* times from financially constrained firms than from average firms. This picture is consistent with Sunday's (2011) study, which shows that for companies with limited financial resources and cash reserves, effective management of the cash conversion cycle is essential for survival if they are to avoid sliding into insolvency. Thus, it appears that the liquidity of firms with limited access to external financial sources depends on effective inventory and credit sales management. This results in a smaller *WCtoA* (working capital to total assets at the beginning of the period) ratio for financially constrained firms.

Concerning the shock period, the working capital components of the firms, regardless of the financial constraint, seem to react similarly except in the case of *DSO*, where non-financially constrained firms extend their *DSO* compared to average firms. This might indicate that these financially strong firms allow time for their supply chain partners (customers) to adjust to the shock. However, if strong firms are less pressured to cut margins, this would also increase *DSO*.

To investigate if financially established firms are capable of smoothing the effects of an adverse cash flow shock themselves, we take a closer look at the different investment policies. Given that financially constrained firms did not use external sources to build up liquidity positions in current assets, we expect non-constrained firms to invest a higher portion of (external) money in working capital. The need to refinance due to longer *DSOs* compared to average companies implies other short-term financing mechanisms. Such short-term financing could be realized, for example, through reverse factoring solutions, as was also observed in the COVID-19 crisis (Moretto and Caniato 2021).

During the shock, constrained firms remained highly exposed to the cash flow from financing. Yet, the high fixed investment sensitivity resulted in a reduction in *ItoA* (ratio of investments to the total assets at the beginning of the period) relative to average firms. Surprisingly, constrained firms adjusted their *WCtoA* similarly to average firms while non-constrained firms cut *WCtoA* relatively more than average firms. Thus, funds freed from working capital were used to smooth the adverse cash flow shock. Perhaps the reduced working capital increases its marginal adjustment cost, forcing firms to disinvest fixed assets more aggressively. The possible aggressive disinvestment of fixed assets by financially constrained firms may be an often-overlooked reason why waves of insolvencies after economic downturns do not materialize or start much later (Lorié and Ciobica 2021).

Firms react differently depending on their financial constraints and investment policies. This supports the results of Fazzari et al. (1988) and Bernanke et al. (1996). Therefore, we can determine that our second proposition PP_2 is tenable, as working capital is used to buffer the shock for fixed investments.

6.3. Working Capital Perspectives on Self- and Supply Chain Orientation

Our research setting and results also allow us to speculate whether companies are more likely to take the traditional perspective of self-orientation or more holistically take into account their supply chain partners in economic downturns. If they follow the traditional perspective, most firms are tempted to reduce their CCC to increase their individual cash

flow. The reduction in *DSO* as well as *DIH* can be used to improve liquidity. Furthermore, an extension of *DPO* could be used to transfer capital costs and transaction risks to upstream suppliers. Although this self-oriented firm view provides diverse opportunities for effective working capital management, reducing working capital will affect the capabilities for fixed investment smoothing during an adverse cash flow shock.

To compare the self-oriented and the supply chain-oriented views, we assume that the supply chain-oriented view aims for value creation through inter-firm collaboration. Here, an extended *DSO*, shortened *DPO* and extended *DIH* are expected. There could be distinct chain reactions that would reveal the attitude. In the case of the supply chain-oriented view, the chain reactions would be: a stronger buffer of working capital → more capabilities for fixed investment smoothing during an adverse cash flow shock → more aggressive reduction in working capital investment and less aggressive reduction fixed investments. Controversy, in the case of the self-oriented firm view: reduced working capital → more limited capabilities for fixed investment smoothing during an adverse cash flow shock → more aggressive reduction in fixed investments. The interplay between these two perspectives can also be described by the basic definition of supply chain financing (Rogers et al. 2020): "to fund" the organization by the supply chain (self-oriented firm view) and "to fund" the supply chain by the organization (supply chain-oriented view).

Perhaps surprisingly, the evidence implies an implementation of the supply chain-oriented view in the financial crisis. Overall, *DPO*, *DIH* and *CCC* behave as the supply chain orientation would predict. In the case of *DSO* that overall acts as self-orientation indicates, the financially non-constrained firms behave more similar to the supply chain-oriented view. In the case of *WCtoA* and *ItoA,* the comparison of the non-constrained and the constrained firms to the average firms seems to also support the supply chain orientation. Overall, non-financially constrained firms behave more similar to the supply chain orientation than average firms and also perform better. Therefore, the supply chain orientation also seems to pay off in terms of working capital management in times of crisis (Hofmann et al. 2021).

7. Conclusions

7.1. Findings and Theoretical Contributions

This article gives insights into working capital management considering the financial constraints and the different phases of a business cycle. As expected, our analysis shows that financially strong firms perform better than average firms; longer *DSO* (as a concession to customers) and smaller *DIH* (as a resilience sign of melting stocks) result in better overall financial performance. Surprisingly, *DPO* was not observed to affect financial performance. Furthermore, our study suggests that financially constrained firms have shorter *DSO* than average firms, which is interpreted as a sign of the struggle for survival.

In economic downturns, firms seem to reduce both working capital and fixed investments to asset ratios. However, the financially constrained firms pushed down their fixed investments ratio more aggressively than average firms, while the most financially robust firms pushed down the working capital to asset ratio. Although these investment ratios went down, this was not the case for the cash conversion cycle as could be expected. This contradictory finding might be due to a computational effect. As is generally known, the components of the *CCC* are calculated using a simple count-back method based on annual figures. During an economic downturn, firms sold and purchased less. Firms also probably tried to adjust their payment terms, but these changes could not fully mitigate the effects of the cash conversion cycle. Furthermore, neither the cash conversion cycle, *DPO*, company performance nor fixed investments to asset ratios fully returned to the pre-shock level.

High stocks of working capital buffer the negative cash flow effect on fixed investments, but firms with relatively limited cash reserves reduce fixed investment. It is further debatable if the use of working capital buffer should be favored if a firm does not face financial constraints. On one hand, an isolated self-oriented firm view suggests reducing working capital (Shin and Soenen 1998), even if this is at the expense of the associated

partners in the supply chain. Alternatively, the supply chain-oriented view suggests value in inter-firm financing depending on the firm's individual cost of capital. The latter was already supported by Meltzer (1960) and is stressed by, e.g., (Hofmann and Kotzab 2010; Wuttke et al. 2013; More and Basu 2013; Blackman et al. 2013; Hofmann and Zumsteg 2015; Huff and Rogers 2015; Peng and Zhou 2019; and Hofmann et al. 2021). Our findings indicate behavior well in line with supply chain orientation—this is especially true among financially strong firms. Overall, research focusing on supply chain-oriented working capital management is gaining increasing attention (Wetzel and Hofmann 2019).

7.2. Practical and Policy Contributions

As for managerial implications, the results highlight the considerations when managing working capital in terms of financial constraints with implications to supply chain partners. Working capital management depends, among other things, on the relative degree of availability of external funds, one's supply chain and the cost of capital. At least, if easy access to the debt and commercial paper market exists, it might pay to provide trade credit, faster payments and stock buffer transfers to the more financially constrained suppliers and customers. The liquidity required for this could be provided via supply chain financing instruments (Rogers et al. 2020), such as the instruction of dynamic discounting (with own cash) or the solutions of reverse factoring or sale of receivables (via money from financial service providers or institutional investors). Contrarily, financially constrained firms might urge their supply chain partners not to utilize their bargaining power to dictate payment and delivery terms (Hofmann et al. 2021). As information asymmetry is typically reduced when dealing within the supply chain when compared to external financial intermediaries, this can be leveraged by sharing, among supply chain members, the avoided risk premium charged by external parties. Our findings are helpful for decision-makers in revising the optimal level of cash according to an economic downturn-related fluctuation in net working capital. When determining the adequate level of net working capital, the classic levers of the cash conversion cycle (*DSO*, *DIH*, *DPO*), the financial restraints and the possibility of liquidating fixed assets must be considered. In addition, the affiliated supply chain partners' financial situations must also be considered. Additionally, policymakers can use these results to recognize that trade credit support is needed in economic downturns. The government's numerous direct and indirect support measures in the early phase of the COVID-19 crisis are evidence of this (Anderson et al. 2021; Khan 2022).

7.3. Limitations and Future Research

As with any investigation, this study must deal with limitations. Tobin's Q was calculated using market capitalization, necessitating that all analyzed firms were stock listed, resulting in the sample being relatively large and well established. The levels of financial constraints might be even more distinct if private firms were included. When defining the key metrics of working capital (especially *DPO* and *DIH*), sales were used as a proxy for the cost of sales (i.e., the margin was included). As the margin is also likely to change during an economic downturn, the measure itself might absorb some of the changes, i.e., the true effects might be more substantial than observed. Furthermore, although we found surprisingly strong support for the supply chain-oriented view, our findings are relatively descriptive and do not allow the proper attitude of the firms to be revealed—they merely suggest that firms behave in many senses similar to the supply chain orientation and the financially most robust firms even more than average firms. Another limitation is that we have not included the recent crisis years 2020 to 2022 in our analysis. Finally, we have not included in our analysis (a) the specific "power situation" in the supply chain (i.e., whether the company in question can enforce trade credit terms adjustments) and (b) whether the companies already use supply chain financing instruments (such as dynamic discounting, reverse factoring or the sale of receivables).

As this research found evidence that the supply chain orientation might be gaining popularity, it would make sense to study further whether the supply chain-oriented mindset

concerning financing aspects ("to fund") is genuinely spreading among the firms or whether other possibly selfish dynamics cause the observed behavior. Such a study could perhaps be carried out through a large-scale survey combined with financial data once the current crisis turbulences have passed. Furthermore, it would make sense to extend the research to non-listed firms where the effects of financial constraints on working capital management might be even more prominent. Finally, it would also be desirable to conduct a study to determine whether companies with a robust supply chain orientation are more able to weather economic downturns than companies that (have to) focus primarily on themselves. A moderating factor that should not be underestimated in further investigations could be the existence of supply chain financing practices.

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Appendix A

Table A1. Division of industries into GICS sectors.

Bloomberg Industry Code	GICS Sector	Crisis in 2009, 1 = Yes, 0 = No
Aerospace and Defense	Industrials	1
Automobiles and Auto Parts	Consumer Discretionary	1
Beverages	Consumer Staples	0
Biotechnology and Medical Research	Healthcare	0
Chemicals	Materials	1
Coal	Energy	1
Computers, Phones and Household Electronics	Information Technology	1
Construction and Engineering	Industrials	1
Construction Materials	Materials	1
Containers and Packaging	Industrials	1
Electric Utilities and IPPs	Utilities	0
Electronic Equipment and Parts	Information Technology	1
Food and Tobacco	Consumer Staples	0
Healthcare Equipment and Supplies	Healthcare	0
Homebuilding and Construction Supplies	Materials	1
Household Goods	Consumer Staples	0
Industrial Conglomerates	Industrials	1
Leisure Products	Consumer Staples	0
Machinery, Equipment and Components	Industrials	1
Metals and Mining	Materials	1
Multiline Utilities	Utilities	0
Natural Gas Utilities	Utilities	0
Office Equipment	Industrials	1
Oil and Gas	Energy	1
Oil- and Gas-Related Equipment and Services	Energy	1
Paper and Forest Products	Industrials	1
Pharmaceuticals	Healthcare	0
Renewable Energy	Energy	1
Semiconductors and Semiconductor Equipment	Industrials	1
Textiles and Apparel	Consumer Staples	0
Transport Infrastructure	Industrials	1
Water Utilities	Utilities	0

Note

[1] See Q1 2022 U.S. Accounts Receivable and Days Sales Outstanding Industry Report https://www.dnb.com/perspectives/finance-credit-risk/accounts-receivable-aging-report.html (accessed on 1 June 2022).

References

Akhtar, Muhammad Ramzan. 1997. Partnership financing of microenterprises. *International Journal of Social Economics* 24: 1470–87. [CrossRef]

Anderson, Julia, Francesco Papadia, and Nicolas Véron. 2021. *COVID-19 Credit Support Programs in Europe's Five Largest Economies*. Peterson Institute for International Economics Working Paper, (21-6). Washington, DC: Peterson Institute for International Economics.

Baños-Caballero, Sonia, Pedro J. García-Teruel, and Pedro Martínez-Solano. 2014. Working capital management, corporate performance, and financial constraints. *Journal of Business Research* 67: 1–7. [CrossRef]

Barney, Jay B. 2012. Purchasing, supply chain management and sustained competitive advantage: The relevance of resource-based theory. *Journal of Supply Chain Management* 48: 3–6. [CrossRef]

Bastos, Rafael, and Julio Pindado. 2007. An agency model to explain trade credit policy and empirical evidence. *Applied Economics* 39: 2631–42. [CrossRef]

Bernanke, Ben, Mark Gertler, and Simon Gilchrist. 1996. The financial accelerator and the flight to quality. *The Review of Economics and Statistics* 78: 1–15. [CrossRef]

Blackman, Ian, Christopher P. Holland, and Timothy D. Westcott. 2013. Motorola's global financial supply chain strategy. *Supply Chain Management: An International Journal* 18: 132–47. [CrossRef]

Bode, Christoph, Denis Hübner, and Stephan M. Wagner. 2014. Managing financially distressed suppliers: An exploratory study. *Journal of Supply Chain Management* 50: 24–43. [CrossRef]

Borio, Claudio. 2020. The COVID-19 economic crisis: Dangerously unique. *Business Economics* 55: 181–90. [CrossRef]

Bradley, Michael, Gregg A. Jarrell, and E. Han Kim. 1984. On the existence of an optimal capital structure: Theory and evidence. *The Journal of Finance* 39: 857–78. [CrossRef]

Brainard, William C., and James Tobin. 1968. Pitfalls in financial model building. *American Economic Review* 58: 99–122.

Brandenburg, Marcus. 2016. Supply chain efficiency, value creation and the economic crisis—An empirical assessment of the European automotive industry 2002–2010. *International Journal of Production Economics* 171: 321–35. [CrossRef]

Brunnermeier, Markus K. 2009. Deciphering the liquidity and credit crunch 2007–2008. *The Journal of Economic Perspectives* 23: 77–100. [CrossRef]

Busi, Marco, and Umit S. Bititci. 2006. Collaborative performance management: Present gaps and future research. *International Journal of Productivity and Performance Management* 55: 7–25. [CrossRef]

Cantú, Carlos, Paolo Cavallino, Fiorella De Fiore, and James Yetman. 2021. *A Global Database on Central Banks' Monetary Responses to COVID-19*. Basel: Bank for International Settlements, Monetary and Economic Department, vol. 934.

Carpenter, Rober, Steven Fazzari, and Bruce Petersen. 1994. Inventory investment, internal-finance fluctuations, and the business cycle. *Brookings Papers on Economic Activity* 25: 75–138. [CrossRef]

Charitou, Melita Stephanou, Maria Elfani, and Petros Lois. 2010. The effect of working capital management on firm's profitability: Empirical evidence from an emerging market. *Journal of Business & Economics Research* 8: 63–68.

Chen, Tsung-Kang, Hsien-Hsing Liao, and Hui-Ju Kuo. 2013. Internal liquidity risk, financial bullwhip effects, and corporate bond yield spreads: Supply chain perspectives. *Journal of Banking and Finance* 37: 2434–56. [CrossRef]

Chong-Chuo, Chang. 2018. Cash conversion cycle and corporate performance: Global evidence. *International Review of Economics & Finance* 56: 568–81.

Clementi, Gian Luca, and Hugo A. Hopenhayn. 2006. A theory of financing constraints and firm dynamics. *The Quarterly Journal of Economics* 121: 229–65.

D'Avanzo, Robery, Hans Von Lewinski, and Luk N. Van Wassenhove. 2003. The link between supply chain and financial performance. *Supply Chain Management Review* 7: 40–47.

Daellenbach, Hans G. 1986. Inventory control and trade credit. *Journal of the Operational Research Society* 37: 525–28. [CrossRef]

Deloof, Marc. 2003. Does working capital management affect profitability of Belgian firms? *Journal of Business & Accounting* 30: 573–87.

Ding, Sai, Alessandra Guariglia, and John Knight. 2013. Investment and financing constraints in China: Does working capital management make a difference? *Journal of Banking & Finance* 37: 1490–507.

Duchateau, Luc, and Paul Janssen. 1997. An example-based tour in linear mixed models. In *Linear Mixed Models in Practise*. Edited by Verbeke Geert and Molenberghs Geert. New York: Springer.

Echarte Fernández, Miguel Ángel, Sergio Luis Náñez Alonso, Javier Jorge-Vázquez, and Ricardo Francisco Reier Forradellas. 2021. Central banks' monetary policy in the face of the COVID-19 economic crisis: Monetary stimulus and the emergence of CBDCs. *Sustainability* 13: 4242. [CrossRef]

Engblom, Janne, Tomi Solakivi, Juuso Töyli, and Lauri Ojala. 2012. Multiple-method analysis of logistics costs. *International Journal of Production Economics* 137: 29–35. [CrossRef]

Enqvist, Julius, Michael Graham, and Jussi Nikkinen. 2014. The impact of working capital management on firm profitability in different business cycles: Evidence from Finland. *Research in International Business and Finance* 32: 36–49. [CrossRef]
European Commission. 2015. Eurostat, Industrial Production Statistics. Available online: http://ec.europa.eu/eurostat/data/database (accessed on 1 October 2015).
Farris, M. Theodore, II, and Paul D. Hutchinson. 2002. Cash-to-cash: The new supply chain management metric. *International Journal of Physical Distribution & Logistics Management* 32: 288–300.
Fazzari, Steven M., and Bruce C. Petersen. 1993. Working capital and fixed investment: New evidence on financing constraints. *RAND Journal of Economics* 24: 328–42. [CrossRef]
Fazzari, Steven M., R. Glenn Hubbard, Bruce C. Petersen, Alan S. Blinder, and James M. Poterba. 1988. Financing constraints and corporate investment. *Brookings Papers on Economic Activity* 1: 141–206. [CrossRef]
Federal Reserve. 2014. Foreign Exchange Rates. Available online: http://www.federalreserve.gov/releases/h10/hist (accessed on 6 May 2014).
Federal Reserve. 2015. Industrial Production and Capacity Utilization. Available online: https://www.federalreserve.gov/releases/g17/download.htm (accessed on 1 October 2015).
Gonçalves, Tiago, Cristina Gaio, and Frederico Robles. 2018. The impact of working capital management on firm profitability in different economic cycles: Evidence from the United Kingdom. *Economics and Business Letters* 7: 70–75. [CrossRef]
Green, Kenneth W., Ronald McGaughey, and K. Michael Casey. 2006. Does supply chain management strategy mediate the association between market orientation and organizational performance? *Supply Chain Management: An International Journal* 11: 407–14. [CrossRef]
Greer, Bertie M., and Peter Theuri. 2012. Linking supply chain management superiority to multifaceted firm financial performance. *Journal of Supply Chain Management* 48: 97–106. [CrossRef]
Grosse-Ruyken, Pan Theo, Stephan M. Wagner, and Ruben Jonke. 2011. What is the right cash conversion cycle for your supply chain? *International Journal of Services & Operations Management* 10: 13–29.
Guerrieri, Veronica, Guido Lorenzoni, Ludwig Straub, and Iván Werning. 2022. Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages? *American Economic Review* 112: 1437–74. [CrossRef]
Helmuth, Catherine A., Christopher W. Craighead, Brian L. Connelly, Donovan Y. Collier, and Joe B. Hanna. 2015. Supply chain management research: Key elements of study design and statistical testing. *Journal of Operations Management* 36: 178–86. [CrossRef]
Hofmann, Erik, and Herbert Kotzab. 2010. A supply chain-oriented approach of working capital management. *Journal of Business Logistics* 31: 305–30. [CrossRef]
Hofmann, Erik, and Stefan Zumsteg. 2015. Win-win and no-win situations in supply chain finance: The case of accounts receivable programs. *Supply Chain Forum: An International Journal* 16: 30–50. [CrossRef]
Hofmann, Erik, Simon Templar, Dale Rogers, Thomas Y. Choi, Rudolf Leuschner, and Rohan Y. Korde. 2021. Supply chain financing and pandemic: Managing cash flows to keep firms and their value networks healthy. *Rutgers Business Review* 6: 1–23.
Hovakimian, Aarmen, and Gayané Hovakimian. 2009. Cash flow sensitivity of investment. *European Financial Management* 15: 47–65. [CrossRef]
Huff, Jerry, and Dale S. Rogers. 2015. Funding the organization through supply chain finance: A longitudinal investigation. *Supply Chain Forum: An International Journal* 16: 4–17. [CrossRef]
Khan, Safi Ullah. 2022. Financing constraints and firm-level responses to the COVID-19 pandemic: International evidence. *Research in International Business and Finance* 59: 101545. [CrossRef]
Kim, Yoon Hee, and Darren Henderson. 2015. Financial benefits and risks of dependency in triadic supply chain relationships. *Journal of Operations Management* 36: 115–29. [CrossRef]
Lanier, Danny, William F. Wempe, and Zach G. Zacharia. 2010. Concentrated supply chain membership and financial performance: Chain-and firm-level perspectives. *Journal of Operations Management* 28: 1–16. [CrossRef]
Lazaridis, Ioannis, and Dimitrios Tryfonidis. 2006. Relationship between working capital management and profitability of listed companies in the Athens stock exchange. *Journal of Financial Management & Analysis* 19: 26–35.
Lee, Chang Hwan, and Byong-Duk Rhee. 2011. Trade credit for supply chain coordination. *European Journal of Operational Research* 214: 136–46. [CrossRef]
Lind, Lotta, Miia Pirttilä, Sari Viskari, Florian Schupp, and Timo Kärri. 2012. Working capital management in the automotive industry: Financial value chain analysis. *Journal of Purchasing & Supply Management* 18: 92–100.
Lorié, Jhon, and Iulian Ciobica. 2021. COVID-19 government support reinforces zombification. *Journal of Risk Management in Financial Institutions* 14: 345–54.
Meltzer, Allan H. 1960. Mercantile credit, monetary policy, and size of firms. *The Review of Economics and Statistics* 42: 429–437. [CrossRef]
Mena, Carlos, Andrew Humphries, and Thomas Y. Choi. 2013. Toward a theory of multi-tier supply chain management. *Journal of Supply Chain Management* 49: 58–77. [CrossRef]
METI. 2015. Indices of Industrial Production. Available online: https://www.meti.go.jp/english/statistics/tyo/iip/ (accessed on 1 October 2015).
Molenberghs, Geert, and Geert Verbeke. 2005. *Models for Discrete Longitudinal Data*. Berlin and Heidelberg: Springer.
More, Dileep, and Preetam Basu. 2013. Challenges of supply chain finance: A detailed study and a hierarchical model based on the experiences of an Indian firm. *Business Process Management Journal* 19: 624–47. [CrossRef]

Moretto, Antonella, and Federico Caniato. 2021. Can supply chain finance help mitigate the financial disruption brought by COVID-19? *Journal of Purchasing & Supply Management* 27: 100713.
Oseifuah, Emmanuel. 2018. Global financial crisis, working capital management and profitability of non-financial firms listed on the Johannesburg stock exchange, South Africa. *Academy of Entrepreneurship Journal* 24: 1–12.
Peng, Juan, and Zhili Zhou. 2019. Working capital optimization in a supply chain perspective. *European Journal of Operational Research* 277: 846–56. [CrossRef]
Rafuse, Maynard E. 1996. Working capital management: An urgent need to refocus. *Management Decision* 34: 59–63. [CrossRef]
Ramiah, Vikash, Yilang Zhao, and Imad Moosa. 2014. Working capital management during the global financial crisis: The Australian experience. *Qualitative Research in Financial Markets* 6: 332–51. [CrossRef]
Richards, Verlyn D., and Eugene J. Laughlin. 1980. A cash conversion cycle approach to liquidity analysis. *Financial Management* 9: 32–38. [CrossRef]
Rind, Asad Ali, Sabri Boubaker, and Viet Anh Dang. 2021. Is there mimicking behavior in firms' trade credit decisions? *Review of Corporate Finance* 1: 81–134. [CrossRef]
Rogers, Dale. S., Rudolf Leuschner, and Thomas Y. Choi. 2020. *Supply Chain Financing: Funding the Supply Chain and the Organization*. Singapore: World Scientific.
Roh, Joseph, Ryan Krause, and Morgan Swink. 2016. The appointment of chief supply chain officers to top management teams: A contingency model of firm-level antecedents and consequences. *Journal of Operations Management* 44: 48–61. [CrossRef]
Schwartz, Robert A. 1974. An economic model of trade credit. *The Journal of Financial & Quantitative Analysis* 9: 643–57.
Seifert, Daniel, Ralf W. Seifert, and Margarita Protopappa-Sieke. 2013. A review of trade credit literature: Opportunities for research in operations. *European Journal of Operational Research* 231: 245–56. [CrossRef]
Shin, Hyun-Han, and Luc Soenen. 1998. Efficiency of working capital and corporate profitability. *Financial Practice & Education* 8: 37–45.
Simatupang, Togar M., and Ramaswami Sridharan. 2005. An integrative framework for supply chain collaboration. *The International Journal of Logistics Management* 16: 257–74. [CrossRef]
Simon, Sunday, Norfaiezah Sawandi, Satish Kumar, and Magdi El-Bannany. 2021. Economic downturns and working capital management practices: A qualitative enquiry. *Qualitative Research in Financial Markets* 13: 529–47. [CrossRef]
Sunday, Kehinde James. 2011. Effective working capital management in small and medium scale enterprises (SMEs). *International Journal of Business & Management* 6: 271–79.
Tarkom, Augustine. 2022. Impact of COVID-19 exposure on working capital management: The moderating effect of investment opportunities and government incentives. *Finance Research Letters* 47: 102666. [CrossRef]
Van Sickle, John J., and George W. Ladd. 1983. A model of cooperative finance. *American Journal of Agricultural Economics* 65: 273–81. [CrossRef]
Viskari, Sari, and Timo Kärri. 2012. A model for working capital management in the inter-organisational context. *International Journal of Integrated Supply Management* 7: 61–79. [CrossRef]
Vu Thi, Anh-Huyen, and The-Dong Phung. 2021. Capital structure, working capital, and governance quality affect the financial performance of small and medium enterprises in Taiwan. *Journal of Risk Financial Management* 14: 381. [CrossRef]
Wetzel, Philipp, and Erik Hofmann. 2019. Supply chain finance, financial constraints and corporate performance: An explorative network analysis and future research agenda. *International Journal of Production Economics* 216: 364–83. [CrossRef]
Wuttke, David, Constantin Blome, and Michael Henke. 2013. Focusing the financial flow of supply chains: An empirical investigation of financial supply chain management. *International Journal of Production Economics* 145: 773–89. [CrossRef]
Zheng, Michael. 2022. Is cash the panacea of the COVID-19 pandemic: Evidence from corporate performance. *Finance Research Letters* 45: 102151. [CrossRef]