2-1-2014

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James R. Kroes
Boise State University

Andrew S. Manikas
University of Louisville

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Cash Flow Management and Manufacturing Firm Financial Performance: A Longitudinal Perspective

James R. Kroes
Boise State University
College of Business and Economics
1910 University Drive
Boise, ID 83725
(208) 426-1169
jimkroes@boisestate.edu
* Corresponding author

Andrew S. Manikas
University of Louisville
Management Department
College of Business
Louisville, KY 40292
(502) 852-4869
andrew.manikas@louisville.edu

ABSTRACT

A firm's cash flow policies, which manage working capital in the form of cash receivables from customers, inventory holdings, and cash payments to suppliers, are inexorably linked to the firm's operations. Building on earlier research, this study: (i) extends prior studies by examining the relationships between changes in cash flow measures and changes in firm financial performance using a longitudinal sample of firm data; and (ii) investigates the direction of the relationship between quarterly changes in cash flow positions and firm financial performance. This study is conducted using the Generalized Estimating Equations (GEE) methodology to analyze a longitudinal sample of eight quarters of cash flow and financial performance data from 1,233 manufacturing firms. The analyses find that changes in the widely used Cash Conversion Cycle (CCC) metric do not relate to changes in firm performance; however, changes in the less used Operating Cash Cycle (OCC) metric are found to be significantly associated with changes in Tobin's q. This examination of how changes in specific cash flow measures relate to changes in Tobin's q shows that both reductions in Accounts Receivables (measured as Days of Sales Outstanding [DSO]) and reductions in Inventory (measured as Days of Inventory Outstanding [DIO]) relate to firm financial performance improvements that persist for several quarters. Endogeneity tests of whether a firm's cash flow management strategy leads to changes in firm performance or if the cash flow strategy is a byproduct of firm performance suggest that reductions in DSO lead to improved firm financial performance.

1. INTRODUCTION

Cash flow management has become a critical element of many firms' operational strategies (Fisher, 1998; Quinn, 2011). A firm's cash flow policies, which manage working capital in the form of cash receivables from customers, inventory holdings, and cash payments to suppliers, are widely linked to improved firm financial performance (Richards & Laughlin, 1980; Stewart, 1995). While industry has broadly accepted effective cash flow management as a performance improvement mechanism, the preponderance of academic investigations into the link between cash flows and performance examines the issue from a static, benchmarking perspective (Ebben & Johnson, 2011; Farris & Hutchinson 2002, 2003; Moss & Stine, 1993). Namely, although previous efforts propose that adjustments to a firm's cash flow will change the firm's performance, they support these propositions empirically by comparing and contrasting firms utilizing static snapshot measures of cash flow positions and performance. Though this static approach has provided a wealth of insight into the value of effective cash flow management, economic relationships

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tend to be dynamic (Nerlove, 2005). In general, approaches that explore such relationships from a longitudinal panel perspective lead to more accurate inferences and a better understanding of the underlying economic complexities (Hsiao, 2007). Consequently, in this study, the relationships between changes in a firm's cash flow positions and changes in the firm's performance are explored from a dynamic viewpoint.

Prevalent working capital management theory advocates that firms can improve liquidity, and hence their competitive positioning by manipulating their cash flows (Brewer & Speh, 2000; Farris & Hutchinson 2002, 2003; Christopher & Ryals, 1999; Moss & Stine, 1993; Stewart, 1995). Further, a firm's ability to convert materials into cash from sales is a reflection of the firm's ability to generate returns effectively from its investments (Gunasekaran, et al., 2004). Three factors directly influence a firm's access to cash: (i) cash from accounts receivables is not available to firms while they are awaiting customer payments for delivered goods; (ii) cash invested in goods is tied up and not available while those goods are held in inventory; and (iii) cash may be made available to a firm if it chooses to delay payment to suppliers for goods or services rendered (Richards & Laughlin, 1980). Although a firm's cash payments and receipts typically are managed by the firm's finance department, the three factors that influence cash flows are manipulated chiefly by operational decisions (Özbayraka & Akgün, 2006).

Although the literature contains numerous studies that examine the relationship among cash cycles, firm liquidity, and firm financial performance, this study explores several extensions of these previous efforts. First, because prior studies generally examine the relationship between snapshots of cash flow and performance measures from a static benchmarking perspective, this study explores the relationship between longitudinal changes in cash flow metrics and changes in firm financial performance over time. This approach will allow firms to determine which cash flow measures should be monitored and manipulated to track and improve firm performance. Second, because previous empirical cash flow studies typically use datasets from a single time period (and those few studies that utilize multi-period data do not utilize methodologies that adjust for the longitudinal nature of the samples), this study conducts an empirical analysis using a longitudinal data panel analysis methodology. This approach also facilitates the examination of possible time-lags in the relationship between changes in cash flow and firm financial performance. Finally, there is a question of endogeneity regarding whether a firm's cash flow management strategy impacts the firm's performance or whether the cash flow positions are a byproduct of a firm's performance (Deloof, 2003). This issue is examined by conducting Granger causality tests to shed light on the possible direction of the relationship between cash flow management actions and changes in performance.

This analysis focuses on manufacturing firms that are publicly traded on the U.S. stock exchanges. This focus was chosen because manufacturers' positions in the middle of integrated supply chains allow them to influence or be influenced by both suppliers and customers (Swaminathan et al., 1998). These interactions with both suppliers and customers also provide substantial opportunities for payment term flexibility between the parties. Additionally, compared to downstream supply chain partners, manufacturers typically have more inventory flexibility in that they can choose whether to hold inventory as raw materials, work in process, or finished goods (Capkun et al., 2009).

The next section discusses prior literature and develops the theoretical framework. The third section discusses the data sample and the study methodology and the fourth section presents the results. The final two sections discuss the implications of the findings, the limitations of the study, and possible research extensions.

2. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1 Measures and Metrics

A firm's cash flow can be manipulated in three ways: (i) the time from when goods are sold until the revenue is collected by the firm may change; (ii) the firm's inventory levels may change; and (iii) the time that a firm takes to pay its vendors may change. When assessing or manipulating a firm's cash positions, one can monitor either individual measures of each of these three cash flow levers or metrics that are combinations of the three measures. The three measures and two composite metrics defined below represent the measures and metrics that commonly have been utilized in previous cash flow studies:

> <u>Days of Sales Outstanding (DSO)</u>: This measure represents the average time from when a sale occurs until the revenue is collected. It is calculated as the end of period accounts receivable divided by the sales, multiplied by the number of days in a period.

Days of Inventory Outstanding (DIO): This measure captures the average time that goods are held in inventory before they are sold. It is calculated as the end of period value of inventory divided by the cost of goods sold, multiplied by the number of days in a period.

Days of Payables Outstanding (DPO): This measure expresses the average time that a firm takes before paying its creditors. It is calculated as the end of period accounts payable divided by the quarterly purchases, multiplied by the number of days in a period.

Cash Conversion Cycle (CCC): The CCC metric (also called the Cash-to-Cash Cycle) combines the three cash flow metrics to provide an overall indicator of a firm's cash position. It is calculated as the sum of Days of Sales Outstanding and Days of Inventory Outstanding, minus the Days of Payables Outstanding. The CCC represents the time period required to convert cash investments in supplies into cash receipts from customers for goods or services rendered.

Operating Cash Cycle (OCC): The OCC metric uses only a subset of the CCC metric. It is calculated as the sum of Days of Sales Outstanding and Days of Inventory Outstanding. OCC differs from CCC in that it includes only inventory and sales outstanding. It does not consider payables, and therefore equates to the number of days that cash is held as inventory before payment is received from the customer.

Additionally, Table 1details the calculations for each of the measures and metrics.

Insert Table 1 Here

2.2 Prior Cash Flow Management Research

2.2.1 Theoretical commonalities

Insert Table 2 Here

Table 2 summarizes the methods and findings of 12 relevant prior empirical studies that examine the relationship between cash flow and performance from an operations or supply chain management perspective. Although numerous additional academic studies have examined cash flow in many operational contexts, these 12 studies were selected specifically because they attempt to link firm performance with cash flow.

These studies employ a variety of methods to examine different aspects of the cash flow management questions; however, they all share a common theoretical groundwork: the studies assert that effective cash flow management improves a firm's liquidity, which previously has been linked to improved firm financial performance (Gitman et al., 1979). The performance improvements related to increased liquidity result primarily from an improved cash position, better credit, a reduced risk of bankruptcy, and/or the ability to self-finance new business initiatives (Churchill & Mullins, 2001; Moss & Stine, 1993; Richards & Laughlin, 1980; Stancill, 1987). Further, these studies consistently predict that actions that shorten the cash cycle and improve liquidity (i.e., shortening the receivable cycles, shortening inventory holding periods, and extending payment cycles) will improve firm financial performance.

Eleven of the twelve previous investigations detailed in Table 2 examine firms' cash positions using the Cash Conversion Cycle (CCC) metric. Nine of the studies explore these individual measures that comprise the CCC as well as the composite CCC metric itself; however, Moss and Stine (1993) and Ebben and Johnson (2011) examine only the CCC metric. In the study that does not focus on CCC, Churchill and Mullins (2001) examine the Operating Cash Cycle (OCC) metric. The metrics and their component measures are calculated with relative consistency across these papers. The specific relationships between the cash flow measures and metrics and firm performance are discussed below:

Days of Sales Outstanding (DSO) and Firm Performance:

A firm's ability to receive payments from customers for delivered goods or services rendered in a timely manner can improve the firm's liquidity (Gallinger, 1997). The cash received from a firm's customers may be used to invest in activities intended to promote additional sales. Therefore, the more quickly that payments are received (i.e., the shorter a firm's DSO is), the more opportunity the firm will have to pursue such activities (Bauer, 2007). Further, research has shown that when a firm extends the accounts receivables period through the use of credit sales, the risk of collecting the outstanding receivables increases significantly (Tsai, 2011). Based on these factors, working capital management theory commonly predicts that a shorter DSO relates to improved firm financial performance (Churchill & Mullins, 2001; Farris & Hutchinson, 2002, 2003; Stewart, 1995). Although shortening DSO can be viewed as unfavorable to the customer, firms often utilize incentives, such as early payment discounts, in an effort to shorten their DSO cycle without damaging their supplier relationships (Moran, 2011). Previous research supports this view; Wort and Zumwalt (1985) find that payment incentive programs, where a firm willingly accepts less revenue in trade for faster access to cash, improve the probability of payment and reduce risk within the firm.

Days of Inventory Outstanding (DIO) and Firm Performance:

Although widely examined in the literature, the relationship between inventory and firm financial performance is not simplistic (Shah & Shin, 2007). Inventory is an asset, in that firms typically must carry it in order to provide goods to their customers in a timely fashion, which means that reductions in inventory may lead to reductions in customer service. However, by holding inventory, cash invested in inventory is unavailable, and the firm is forced to incur carrying costs; hence, inventory reductions may reduce holding costs and free up cash that can be reinvested to increase sales. Additionally, changes in the inventory levels at a firm have been linked to an increase in the magnitude of the bullwhip effect experienced by partners upstream in a supply chain (Tangsucheeva & Prabhu, 2013). Although inventory reductions have the potential to both damage and improve firm performance, the preponderance of evidence in the literature suggests that shorter inventory holding periods (i.e., lower DIO) generally associate with improved liquidity and better firm financial performance (Capkun et al., 2009; Chen et al., 2005; Koumanakos, 2008; Swamidass, 2007). Further, it has been shown that excessive inventory levels are related to poor operational and financial performance (Singhal, 2005). Although lowering inventory conceptually may seem to expose a firm to a greater risk of stock-outs, in practice, firms often are able to reduce inventories without sacrificing service through methods including Lean/Just-In-Time management programs, automated replenishment systems, Vendor Managed Inventory (VMI) programs, and consignment inventory programs (Achabal et al., 2000; Harrington, 1996; Myers et al., 2000). These types of programs successfully lower inventory levels by substituting additional inventory with better information, which has been shown to reduce inventory levels effectively without damaging performance (Milgrom & Roberts, 1988).

Days of Payables Outstanding (DPO) and Firm Performance:

Like DIO, the relationship between DPO and firm financial performance is complex. Extending the payment cycle clearly will allow a firm to hold on to cash longer, resulting in improved liquidity (Stewart, 1995). However, when a firm extends its payment cycle, it is forgoing early payment discounts and possibly harming its relationships with suppliers (Fawcett et al., 2010). Additionally, when a supplier is starved of cash due to long payment cycles, the overall supply chain may be impacted negatively over the long-term (Raghavan & Mishra, 2011). Longer payment cycles also may be forcing a firm's suppliers to provide lower levels of service (Timme & Wanberg, 2011). Unlike inventory, where a shorter DIO consistently has been linked to improved performance in the literature, the relationship between DPO and performance is less clear in the literature; for example, Farris and Hutchison (2002) use cases to show that higher performing firms have longer DPO periods, and Deloof (2003) and Garcia-Teruel and Martinez-Solano (2007) both empirically find that shorter DPO periods are related to higher firm financial performance.

Cash Conversion Cycle (CCC), Operating Cash Cycle (OCC) and Firm Performance:

The eleven CCC focused studies referenced in Table 2 propose that improved cash flow management (i.e., a shorter CCC) theoretically is associated with improved firm liquidity, and hence with improved firm financial performance. Similarly, Churchill and Mullins (2001) propose that a shorter OCC is also associated with better firm liquidity and performance.

2.2.2 Prior methodologies

The methods used to investigate cash flow management strategies vary substantially across the literature: four of the papers use case-studies (Churchill & Mullins, 2001; Farris & Hutchinson, 2002; Randall & Farris, 2009; Stewart, 1995), seven use correlation and regression to examine empirical samples consisting of annual firm-level data (Deloof, 2003; Ebben & Johnson, 2011; Farris & Hutchinson, 2003; Garcia-Teruel & Martinez-Solano, 2007; Gill et al., 2010, Moss & Stine, 1993; Soenen, 1993), and one presents a hypothetical optimization model (Hofmann & Kotzab, 2010).

Five of the previous studies empirically examine the connections between cash flow management and firm financial performance. These studies employ a variety of financial performance metrics, including Asset Turnover (Ebben & Johnson, 2011), Gross Operating Income (Deloof, 2003), Gross Operating Profit (Gill et al., 2010), Invested Capital (Ebben & Johnson, 2011), Net Balance Position (Ebben & Johnson, 2011), Return on Assets (ROA) (Garcia-Teruel & Martinez-Solano, 2007; Soenen, 1993), and Return on Investment (ROI) (Ebben & Johnson, 2011).

Despite differences in methodologies, several common themes emerge across the studies. In all but two of the studies, the cash flow positions of the firms are assessed using static values of the measures and metrics of interest. None of the empirical investigations examine how changes in a firm's cash position relate to changes in performance. Instead, they compare firms using snapshot measures of cash flow. This is a useful approach if the goal is to benchmark firms against each other, though it does not shed insight into the impact of changes in a firm's cash position on that firm's performance.

2.2.3 Prior findings

The extant body of cash flow management literature finds mixed support for the theoretical predictions on the relationship between cash flow management and performance. Though the widely held belief is that shorter DSO, shorter DIO, and longer DPO relate to better firm financial performance, it is important to note that these beliefs are promoted in the literature largely through case studies or small samplings of firms (Churchill & Mullins, 2001; Farris & Hutchinson, 2002; Randall & Farris, 2009). None of the prior studies that use larger empirical datasets to examine the link between firm financial performance and the CCC's components find the DSO, DIO, and DPO components to be concurrently significant in the predicted directions. Deloof (2003) finds partial agreement with traditional CCC theory by showing shorter DSO and DIO to be associated with higher gross operating income. However, in contrast to predictions, he finds that shorter DPO is significantly associated with higher gross operating income and that CCC has no relation with gross operating income. Similarly, Garcia-Teruel and Martinez-Solano (2007) find that shorter DIO and DSO cycles are associated with higher ROA, agreeing with theoretical predictions; however, they also find a significant association between shorter DPO and higher ROA. Gill et al. (2010) find that a shorter DSO period is associated with higher firm profitability, which agrees with predicted theory; however, they also find that a longer CCC is associated with higher firm profitability.

2.3 Static versus Dynamic Views of Cash Flow Management

Although the previous research efforts discussed above do provide substantial insight into the comparative performance of firms based on their relative cash positioning, they do not explore how changes in the cash flow levers may link to variation in a firm's performance; that is, these investigations, conducted using static measures, do not address if changes in cash flow levers associate with performance changes, if any effects are instantaneous, or if there is a time lag before performance is impacted. As Capkun et al. (2009) note, using longitudinal samples that incorporate differential measurements of key variables over longer time windows helps to explain the impact of operational improvement efforts (in their case inventory performance) on firm financial performance and valuation. The two studies included in Table 2 that partially consider the dynamic nature of cash flow management address only the relationship between changes in cash flow positions and static performance measurements. Ebben and Johnson (2011) examine the association between annual changes in CCC and snapshots of static performance measures, and Garcia-Teruel and Martinez-Solano (2007) test the robustness of their findings by including a single period of lagged cash flow components to also examine static performance measures. Although these two studies begin to explore the dynamic impacts of cash flow management, to the best of this study's authors' knowledge, no prior studies fully investigate the relationship between changes in cash flow measures and changes in performance.

Although the cash flow management studies discussed above do not examine the issue from a dynamic perspective, several related studies examine the performance impacts of changes in inventory positions over time. Capkun et al. (2009) examine inventory changes using 26 years of annual data and find that reductions in inventory over a one year period associate with higher earnings and profits at the end of the year. Lieberman and Demeester (1999) examine the relationship between inventory and productivity for Japanese automotive firms and find that 10% reductions in work in process inventory associate with 1% improvements in productivity with a one-year lag (note that their data were measured annually over four years).

Prior research has questioned the direction of the relationship between cash flow management and performance. Deloof (2003) drew attention to the directional uncertainty of the relationship between cash flow management and firm financial performance when he proposed that changes in a firm's performance might be the driver of changes in the firm's cash flow positions. Specifically [on page 584], he suggested that declining profitability might be the result of lower sales, which could cause a buildup of inventory, and that customers may "…want more time to assess the quality of products they buy from firms with declining profitability." Deloof (2003) also posits that a possible explanation of why longer payables are negatively associated with profitability might be that less profitable firms simply need more time to pay their bills. Although true theoretical causality cannot be proven using statistical methods, tests of the relationships between lagged variables within a longitudinal time-series sample, such as the Granger causality test, may lend additional support for causal inferences (Hult et al., 2008). Granger causality tests examine if lagged values of a variable (X) significantly help to explain the present value of a second variable (Y), and if lagged values of the second variable (Y) significantly relate to the first variable (X). A variable (X) is said to "Granger cause" another variable (Y) if lagged values of X associate with Y, and lagged values of Y do not associate with X (Granger, 1969).

2.4 Research Hypotheses

Building on earlier research, this study attempts to address the gaps identified in prior studies by: (i) examining the temporal relationships between changes in cash flow measures and changes in firm financial performance using a more granular quarterly (versus annual) level longitudinal sample of firm data; and (ii) investigating the direction of the relationship between quarterly changes in cash flow positions and firm financial performance.

2.4.1 Analysis of cash flow position changes and changes in firm financial performance

In an effort to understand how cash flow management decisions relate to changes in an organization's performance, this study examines how changes in cash flow metrics and measures relate to changes in firm financial performance over time. The analysis provides insights into the most effective tactics that firms might employ to improve their own performance by manipulating their working capital positions. For the cash flow levers, previous theory predicts that a shorter DSO and a shorter DIO will relate to better firm financial performance. This study extends this contention and predicts that reductions in DSO or DIO over a calendar quarter will associate with continuing improvements in financial performance. Similarly, it is predicted that reductions in CCC or OCC over a quarter also will relate to lasting financial performance improvements. Due to the confounding theory surrounding DPO, predictions are not made regarding the relationship between changes in DPO and changes in firm performance. Previous literature provides little guidance for predicting the duration of performance changes resulting from changes in a firm's cash flow. In the most relevant studies, both Lieberman and Demeester (1999) and Capkun et al. (2009) find that changes in inventory led to immediate performance improvements for firms that continue into the results for the next year. Using these studies to determine the exact duration of lag effects with greater precision is hindered as they utilize annual data for their analyses. However, based on their findings, it can be expected that reductions in DIO will correspond with immediate improvements in firm financial performance, which will continue for up to one year. Likewise, as changes in the DSO measure or the CCC and OCC metrics have an impact similar to DIO's impact on a firm's liquidity and performance, it is expected that changes in these variables also should correspond with immediate performance improvements that will continue for up to one year. Thus, it is posited that:

H1A: A reduction (increase) in the Days of Sales Outstanding period will associate with an immediate improvement (decline) in firm financial performance that persists for up to one year.
H1B: A reduction (increase) in the Days of Inventory Outstanding period will associate with an immediate improvement (decline) in firm financial performance that persists for up to one year.
H1C: A reduction (increase) in the Cash Conversion Cycle will associate with an immediate improvement (decline) in firm financial performance that persists for up to one year.
H1D: A reduction (increase) in the Operating Cash Cycle will associate with an immediate improvement (decline) in firm financial performance that persists for up to one year.

2.4.2 Granger causality analysis

In the second analysis, post-hoc Granger causality tests are conducted to determine if there is additional support for the directional prediction, that firm financial performance is influenced by changes in a firm's cash flow position, rather than the converse proposition that changes in firm financial performance cause changes in a firm's cash flow position. As these causality tests are post-hoc, this analysis will test only measures and metrics found to be significant in the analysis of the previous set of hypotheses.
H2A: Changes in significant cash flow measures will Granger cause changes in firm financial performance.
H2B: Changes in significant cash flow metrics will Granger cause changes in firm financial performance.

3. MEASURES AND METHODS

3.1 Sample and Data

Quarterly firm-level financial data reported by publicly traded manufacturers in the COMPUSTAT database is used to construct the longitudinal data panel (Standard and Poor's, 2011). The use of quarterly data in these analyses is intended to provide greater granularity in the findings than previous studies that use annual data only. The sample includes data for manufacturing firms, that is, firms with two-digit SIC codes ranging from 20 to 39. An issue with this approach of investigating quarterly changes within firms is that a firm cannot have any missing data items over the entire sample period, as any missing data will result in calculation errors and an unbalanced data panel. This issue led to the choice of a 12 quarter observation window (two years plus one year of lagged data), as it provides a robust sample period from which valid inferences can be made, while limiting the number of firms that would need to be dropped due to missing data. At the initiation of this study, the second quarter of 2011 represented the most recent period of complete data availability (there is typically a six-to-nine month delay before a firm's final information is uploaded to the COMPUSTAT database). For each firm, the static measures of the variables of interest are collected for the 12 quarter period beginning at the end of the third calendar quarter of 2008 (as opposed to the firm's fiscal quarter, which often varies among firms) and ending at the end of the second calendar quarter of 2011. The change in each of the cash flow variables across each of the latest eight quarters of data and the lagged values of the quarterly changes in the cash flow variables for the previous four quarters are measured for each firm.

The descriptions, calculations, and descriptive statistics for the measures are presented in detail in Table 1. The initial data sample represented 1,927 unique firms that reported data over the entire 12-quarter observation period; however, 694 firms were removed from the sample as they did not report complete data for all 12 quarters of the study period. The resulting sample includes 1,233 manufacturing firms publicly traded on U.S. stock exchanges. The firms in the sample average $987 million in quarterly sales (with a median of $110 million per quarter).

3.2 Measures

The cash flow metrics and measures used in this study are consistent with those found in previous studies; the *DIO*, *DPO*, *DSO*, *CCC*, *OCC*, and firm financial performance across 12 quarters are measured for each firm in the sample. These static values then are used to compute the quarterly changes in the cash flow and firm financial performance variables (ΔDSO, ΔDIO, ΔDPO, ΔCCC, ΔOCC, and firm financial performance).

The financial performance of the firms in this study is measured using Tobin's q metric. Tobin's q, which is the ratio of the market value of a firm to the replacement value of its assets, has been employed widely as an indicator of firm financial performance (Lindenberg & Ross, 1981; Dowell et al. 2000; Hennessy, 2004; Kroes et al., 2012). A higher Tobin's q value represents superior firm financial performance. Several factors drove the decision to choose Tobin's q over other performance metrics such as ROA or profit. First, Klingenberg et al. (2013) have shown that traditional accounting measures such as Return on Assets, Return on Equity, and inventory ratios may not be suitable metrics when assessing the link between inventory changes and performance. Additionally, Tobin's q has been shown to be superior to accounting measures such as ROA as an indicator of relative firm performance (Wernerfelt & Montgomery, 1988). Finally, as this study investigates the long-term implications of cash flow management strategies, Tobin's q was appropriate particularly because of its incorporation of the market value of a firm, which reflects the expected value of the future firm profits (Lindenberg & Ross, 1981). In this analysis, the financial performance of the firms in the sample is compared using the actual changes in their Tobin's q values. In similar investigations that examine firms across industries, industry-specific firm performance portfolios are used often; however, this was not necessary as this study focuses on the manufacturing industry only.

The models are controlled for debt loading and firm size. From a cash flow perspective, firms with high levels of debt may not benefit fully from improved working capital management policies because any cash that is freed up might need to be redirected from operational activities to meet their debt obligations (Capon et al., 1990). The ratio of a firm's Total Long-term Debt to Total Assets is included to control for this possibility. Firm size also has been shown to impact the market valuation of a corporation (Dowell et al., 2000; King & Lenox, 2002). To control for firm size, this study adopts the approach used in both Ehie and Olibe (2010) and Hendricks and Singhal (2003) and utilized Quarterly Sales as a proxy to control for firm size. The choice of Quarterly Sales over Total Assets as the proxy for firm size was made to avoid potential multicollinearity issues because Total Assets is the denominator of the dependent variable. Note that in this analysis, the natural log of Quarterly Sales is used, as a non-linear relationship between Quarterly Sales and Tobin's q was discovered in the data sample.

3.3 Methodology

Analyses of repeated-measures panel data samples typically utilize either subject-specific techniques such as random-effects modeling and fixed-effects modeling or population-averaged techniques such as generalized estimating equations (GEEs) (Gardiner et al., 2009). Each of these methods offers particular advantages that depend on the nature of the data sample and the desired research focus (Hu et al., 1998). A particular advantage of GEEs is their ability to robustly estimate the regression coefficient's variances for data samples exhibiting high correlation between repeated measurements (Ballinger, 2004; Ghisletta & Spini 2004; Hu et al., 1998). This advantage led to the use of GEEs in this study, as the repeated measurements in the data sample are highly correlated between quarters. In practice, the parameter estimations (and statistical significance) generated using these three methods usually are consistent for large samples with little missing data; however, the inferences obtained using GEEs differ subtly from those obtained using subject-specific models (Zeger & Liang, 1986). Specifically, the GEEs population-averaged approach will estimate the average impact of cash flow management decisions on performance across the population of manufacturing firms, and the parameters generated using a subject-specific technique (i.e., fixed-effects or random-effects models) will estimate the relationship between cash flow management and performance for an individual firm (Hubbard et al., 2010). Although the GEE approach is well suited for this study, the fixed-effect versions of each of the models are evaluated as well to test the robustness of the findings.

3.3.1 Analysis of dynamic cash flow management and lag effects

The data sample includes observations across eight quarters from publicly traded manufacturing firms (which, in actuality, spans twelve quarters due to the inclusion of four quarters of lagged variables within each observation). For each firm *i*, the dependent variable, $Y_{it} = \Delta TOBINS\_Q$ is measured across *n* quarters (*n* = 8 quarters) where *t* represents the quarter. The $\Delta TOBINS\_Q$ values for each firm *i* form the vector $Y_i = (Y_{i1}, \ldots, Y_{in})'$ where each Y_{it} is a scalar. The predictor variables (*ΔDSO, ΔDIO, ΔDPO, ΔCCC, ΔOCC*), lagged values of each predictor for the previous four quarters, and control variables (*DEBT* and ln[*SALEQ*]) for each firm *i* are measured across the same eight quarters, forming the vector $X_i = (X'_{i1}, \ldots, X'_{in})'$ where X'_{it} is a vector of the independent variables included in a specific model. To model and test the relationships of interest between the dependent variable and the independent variables, GEEs use a link function. Depending on the distribution of the dependent variable, various link functions can be specified to linearize the relationship between the dependent and predictor variables. In the dataset, the independent and dependent variables are normally distributed; therefore, the analyses utilizes the non-transforming identity link function $g(\mu_i) = \boldsymbol{X}_i B$, where $\mu_i = E(Y_i \mid X_i)$, and β denotes the vector of regression coefficients ($\beta_1, \ldots, \beta_k$) estimated using the GEE procedure.

The GEE technique estimates the model parameters (βs) through an iterative procedure that optimizes the fit of the data to the model (Hardin & Hilbe, 2003) such that:

$$\sum_{i=1}^{n} D_i' V_i^{-1} (Y_i - \mu_i) = 0 \qquad (1)$$

where $D_i = \delta\mu_i(\beta)/\delta\beta'$ and V_i represents the working covariance matrix of Y_i. V_i also may be stated as $V_i = A_i^{1/2} R(\alpha) A_i^{1/2}$, in which A_i represents a diagonal vector containing the values of $var(Y_{ij})$ and $R(\alpha)$ is the assumed working correlation matrix specified for the analysis (Pan, 2001). Repeated time-series financial measurements, such as the components of cash flows, exhibit a first-order autoregressive correlation between time periods (Hui et al., 1993). Therefore, the working correlation matrix $R(\alpha)$ is defined using the first-order auto-regressive *AR(1)* specification (Zeger & Liang, 1986). For robustness, the analyses were duplicated using an unstructured and an independence correlation model.

The first model investigates the three component cash flow measures (DSO, DIO, and DPO), and the last two models investigate the CCC and OCC metrics, respectively. The change (Δ) in a variable for period *t* is measured as the difference between its value at the end of the quarter and its value at the end of the previous quarter. The models are specified as:

Component Model:

$$\Delta TOBINS\_Q_{it} = \beta_0 + \beta_1(lnSALEQ_{it}) + \beta_2(DEBT_{it}) + \beta_3(\Delta DSO_{it}) + \beta_4(\Delta DSO_{it-1}) + \beta_5(\Delta DSO_{it-2}) + \beta_6(\Delta DSO_{it-3}) + \beta_7(\Delta DSO_{it-4}) + \beta_8(\Delta DIO_{it}) + \beta_9(\Delta DIO_{it-1}) + \beta_{10}(\Delta DIO_{it-2}) + \beta_{11}(\Delta DIO_{it-3}) + \beta_{12}(\Delta DIO_{it-4}) + \beta_{13}(\Delta DPO_{it}) + \beta_{14}(\Delta DPO_{it-1}) + \beta_{15}(\Delta DPO_{it-2}) + \beta_{16}(\Delta DPO_{it-3}) + \beta_{17}(\Delta DPO_{it-4}) + e_{it} \qquad (2)$$

CCC Model:

$$\Delta TOBINS\_Q_{it} = \beta_0 + \beta_1(lnSALEQ_{it}) + \beta_2(DEBT_{it}) + \beta_3(\Delta CCC_{it}) + \beta_4(\Delta CCC_{it-1}) + \beta_5(\Delta CCC_{it-2}) + \beta_6(\Delta CCC_{it-3}) + \beta_7(\Delta CCC_{it-4}) + e_{it} \qquad (3)$$

OCC Model:

$$\Delta TOBINS\_Q_{it} = \beta_0 + \beta_1(lnSALEQ_{it}) + \beta_2(DEBT_{it}) + \beta_3(\Delta OCC_{it}) + \beta_4(\Delta OCC_{it-1}) + \beta_5(\Delta OCC_{it-2}) + \beta_6(\Delta OCC_{it-3}) + \beta_7(\Delta OCC_{it-4}) + e_{it} \qquad (4)$$

where *i* in the equations above represents the index for firms and *t* represents the index for the quarter.

3.3.2 Granger causality analysis

Next, the analysis tests for Granger causality between changes in cash flow metrics and measures found to be significant in the previous analysis and changes in firm financial performance. The longitudinal nature of the data sample facilitates the testing of Granger causality to help support or refute the plausibility of the directional theoretical predictions that changes in cash flow positions lead to changes in firm performance. To conduct these tests, GEEs again are used to determine if lagged values of the changes in significant cash flow measures and metrics help to explain firm performance changes (ΔX → ΔY), and vice versa (ΔY → ΔX). A combination of significance for lagged ΔXs in the ΔX → ΔY test and non-significance of lagged ΔYs in the ΔY → ΔX test indicates that ΔX Granger causes ΔY.

4. RESULTS

The model parameters in the study were estimated using SPSS v.19's Generalized Estimating Equation procedure. All of the GEE models' parameter estimations converged within 50 iterations.

Insert Table 3 Here

The analysis of quarterly changes in the three cash flow measures and their association with changes in firm performance, detailed in Table 3, finds that changes in both DSO and DIO are negatively and significantly associated with changes in Tobin's q (supporting H1A and H1B). An examination of the lagged quarterly changes in the cash flow measures shows that changes in DSO are significantly and negatively associated with changes in Tobin's q from the current quarter through the three prior quarters (indicating that changes in DSO associate with performance changes that persist for up to 12 months), and changes in DIO are significantly and negatively associated with performance changes for the current and previous quarters only (implying that changes in DIO relate to performance changes that persist for up to six months). Quarterly changes in DPO are not significantly associated with performance changes across the time periods examined by the model.

Insert Table 4 Here

Table 4 reports the results of the analyses of how changes in CCC and OCC relate to performance changes. The results show that changes in CCC in the current and previous quarters do not relate to performance changes in the current quarter, rejecting H1C. The analysis does show support for H1D, as reductions in OCC during the current and three prior quarters are negatively and significantly associated with firm financial performance changes in the current quarter (suggesting that changes in OCC associate with performance changes that persist for up to one year).

Insert Table 5 Here

Table 5 presents the post-hoc Granger causality analysis results for the significant cash flow measures (ΔDSO and ΔDIO). First, the theoretically predicted relationship that changes in cash flow measures cause changes in firm performance (ΔX → ΔY) is examined. The first model, which is the initial model for both the ΔDSO and ΔDIO models, finds that lagged values of quarterly changes in Tobin's q do help explain Tobin's q changes in the current quarter (reported in the first column of parameter estimates in Table 5). The next analysis finds that the addition of lagged values of both ΔDSO and ΔDIO to the initial model both significantly relate to firm performance changes in the current quarter (reported, respectively, in the second and third columns of parameter estimates in the table). Next, the inverse of the theoretically predicted relationship between cash flow changes and firm performance (ΔY → ΔX) is tested. The fourth and sixth columns of parameter estimates in the table show that lagged values of ΔDSO and ΔDIO explain changes in the current quarter's DSO and DIO. Finally, lagged ΔTobin's q is added to these two models, which shows that lagged values of ΔTobin's q do not significantly explain changes in the current quarter's DSO; in contrast, a significant relationship is found between lagged changes in firm performance and changes in the current quarter's DIO. From these results, it can be concluded that ΔDSO Granger causes ΔTobin's q. However, Granger causality is not supported for ΔDIO, and the direction of the relationship between ΔDIO and ΔTobin's q is unclear. These findings lend mixed support for H2A.

Insert Table 6 Here

The final analysis examines the relationship between ΔOCC and ΔTobin's q for Granger causality. As shown in Table 6, the analysis first replicates the test of lagged values of ΔTobin's q on the current quarter's ΔTobin's q. Next, lagged values of ΔOCC are added to the model (the second column of parameter estimates) and find that they significantly explain changes in the current quarter's ΔTobin's q. The analysis then tests the inverse direction of the theoretically predicted relationship and finds that lagged values of ΔTobin's q, in the presence of lagged values of ΔOCC, do not explain changes in the current quarter's OCC. These results lead to the conclusion that ΔOCC Granger causes ΔTobin's q, in support of H2B.

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Two additional analyses were conducted to test the robustness of the findings. When the GEE models were tested using the alternative independence and unstructured working correlation matrices, the significance and sign of the parameter coefficients were consistent with the results obtained using auto-regressive specification. Similarly, the support for the hypotheses determined using the fixed-effects methodology does not vary from the results of the GEE analysis. The detailed results of the fixed-effects robustness analyses are presented in the Appendix.

5. DISCUSSION AND IMPLICATIONS

The findings from the analyses, which show that reductions in both DSO and DIO associate with positive improvements in firm financial performance (and that changes in DPO do not relate to performance changes), provide additional insight into the importance of cash flow management for manufacturers. As reported in the previous section, reductions in DSO relate to immediate improvements in Tobin's q that continue for three additional quarters, and ΔDSO Granger causes ΔTobin's q. In combination, these two findings provide strong evidence that when a firm shortens its DSO through better relationships with customers and other methods, the firm may experience a prolonged period of continuing firm financial performance improvement that persists for up to one year. This might be the result of a combination of factors. First, reducing DSO improves a firm's liquidity, which permits the firm to invest in new business growth opportunities, the implementation and benefits of which may require several quarters to materialize. Second, DSO reductions, which often involve improving customer relationships and communications, represent sustainable longer-term improvements for both parties that likely will continue for extended periods of time.

In contrast to DSO, the findings for DIO do not provide as clear a picture of its relation to firm performance. First, the lag effects of changes in DIO and significant changes in performance span only the current and previous quarter. The difference in the nature of DIO reductions might help explain why DIO changes appear more ephemeral than DSO changes. Like efforts to reduce DSO, inventory reductions are often the result of longer-term efforts, such as VMI implementations or shifting inventory ownership to suppliers or customers, which will have a lasting impact on performance. However, these longer-term inventory reduction programs may be balanced by immediate inventory reductions, such as obsolete stock write-offs, which likely will have a shorter-term impact on the firm. The lack of a clear Granger causality result for DIO also leaves open the question of endogeneity – although the results do support that changes in DIO may lead to changes in firm performance, they also support the converse argument proposed by Deloof (2003), that changes in firm performance may lead to reductions in inventory levels. Granger (1969) presents two possible explanations for relationships of this nature. First, a feedback mechanism may exist; for example, in this scenario, as firm performance improves, the firm builds a larger and more stable customer base, which leads to more consistent demand, thus improving the firm's ability to predict the appropriate product mix and fill rates, allowing it to carry less inventory, which then further improves its performance, and so on. Second, the apparent bi-directional causality may be the result of some additional factor, not considered in the models, that influences changes in both inventory levels and firm performance. For example, an organizationally encompassing lean improvement program might simultaneously reduce inventory levels and improve firm financial performance.

The lack of significance found for changes in DPO falls in line with previous research, which finds mixed results for the DPO measure; however, the finding contradicts the widely held belief that extending payment cycles improves firm liquidity and performance. Although longer payment cycles clearly improve a firm's immediate liquidity, a substantial body of prior literature argues that such practices eventually may impact a firm negatively. Hofmann and Kotzab (2010) show that that companies that lengthen their cash conversion cycles by implementing self-serving working capital initiatives often do so at the expense of their supply chain partners. Particularly, when firms extend their payables cycle to improve cash liquidity, they are negatively impacting the receivables cycle of their suppliers, which likely will deteriorate the quality of a firm's supplier relationships. For example, a vendor may be inclined to provide lower service and less flexibility in meeting demands for a customer that is slow to pay. Although these arguments support policies that shorten DPO, it is important to recognize that this study's results did not find any significant relationship between DPO and firm performance. This may suggest that there may be a point for DPO that balances the benefits of improved firm liquidity with the impact on supplier relationships. Previous research supports this view. As Baur (2007) notes, there is a balance between extending payables to improve a firm's cash position versus paying earlier to take advantage of earned discounts. Further, Moran (2011) suggests that taking advantage of early payment discounts may be more beneficial for a firm than extending the payment cycle because they lower the effective purchase price for materials and components.

The analysis found that changes in the CCC did not translate into significant changes in firm performance. The lack of significance for changes in the CCC implies that changes in the payables cycle appear to mute the combined impact of changes in receivables and inventory cycles. For managers, this finding intimates that reducing the CCC only by reducing DPO likely will not translate into improved firm performance.

In contrast, changes in the OCC metric were significantly and negatively associated with changes in firm performance for a period lasting four quarters. This result is not surprising due to the lasting significance of both of ΔOCC's components (ΔDSO and ΔDIO). Despite the lack of clarity of the endogeneity of the ΔDIO component of ΔOCC, the finding that ΔOCC Granger causes changes in firm performance provides strong support for the use of ΔOCC: (i) as a metric for managers to monitor performance; and (ii) as a lever to manipulate to improve a firm's performance. Specifically, firms should concentrate on reducing their receivables and inventory cycles when attempting to improve performance cash positions adjustments.

6. CONCLUSIONS AND FUTURE RESEARCH

This research into the relationships between changes in cash flow management and firm performance proposes an enriched method for measuring and managing a firm's cash positions. The examination of the temporal impacts of changing these metrics shows ΔOCC to be a superior tool for managers. Similarly, both ΔDSO and ΔDIO were shown to be effective measures for managing cash flows; however, ΔDPO was not found to be related significantly to firm performance changes. Managers may use these measures and metrics in two ways: (i) they should monitor ΔDSO, ΔDIO, and ΔOCC, as changes in these indicators are likely to impact the firm's performance; and (ii) they should develop management strategies to manipulate these levers to improve firm performance.

This study is limited in that it examines only manufacturing firms. Future extensions of this work might examine if the cash flow management policies of firms in other areas of the supply chain have similar relationships with firm performance. In addition, an investigation to further explore the directional nature of the relationship between inventory and performance changes might extend the understanding of the role that cash flow management may play in the success of firms.

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Table 1: Data and measures.

Measure	**Abbreviation**	**Description**	**Calculation**	**Sample Mean (std. dev.)**	**Avg. Quarterly Change [Δ] (std. dev.)**
Days of Sales Outstanding (DSO)	*DSO*	The average number of days required to collect revenue after a sale is made.	(Accounts Receivables ÷ Sales) x (# of days in a period)	59.7 days (453.6)	-0.2 days (561.2)
Days of Inventory Outstanding (DIO)	*DIO*	The average number of days that inventory is held before it is sold.	(Inventory ÷ Cost of Goods Sold) x (# of days in a period)	97.1 days (176.0)	-0.4 days (211.2)
Days of Payables Outstanding (DPO)	*DPO*	The average number of days a company takes to pay creditors.	(Accounts Payable ÷ Purchases) x (# of days in a period) Purchases = (Cost of Goods Sold + Change in Inventory)	66.7 days (257.1)	-2.65 days (224.7)
Cash Conversion Cycle (CCC)	*CCC*	The duration (in Days) required to convert cash invested in supplies into cash collected from customers.	Days Sales Outstanding + Days Inventory On-Hand - Days Payables Outstanding	90.0 days (551.6)	2.02 days (638.9)
Operating Cash Conversion (OCC)	*OCC*	The duration (in Days) that cash is tied up in working capital before payment is received from customers.	Days Sales Outstanding + Days Inventory On-Hand	156.8 days (486.5)	-0.63 days (600.1)
Tobin's q	*TOBINS_Q*	Firm's market value per dollar of replacement cost of assets.	(Equity value + book value of long-term debt + net current liabilities) ÷ (Value of total assets)	1.7 (1.2)	-0.26 (0.58)
Quarterly Sales	*SALEQ*	Firm size (Quarterly sales in $Million (MM)).	Net quarterly sales ($)	987.4 (3,790.9)	N/A
Debt to Assets Ratio	*DEBT*	Ratio of debt to total firm assets.	(Total long-term debt ÷ Total assets)	0.16 (0.22)	N/A

Table 2: Prior cash-flow management studies.

Authors & Year	Sample or Data Source	Methodology	Primary Findings
Churchill & Mullins (2001)	Snapshot of financial data for several case firms.	Case-examples	Examines how the Operating Cash Cycle (OCC) can be used as a metric to determine the growth potential of firms.
Deloof (2003)	Financial data for 1,009 large non-financial Belgian firms.	Correlation and Regression	Shorter DIO, DSO, and DPO are each associated with higher Gross operating Income. CCC is not significantly associated with Gross operating Income.
Ebben & Johnson (2011)	Annual financial data for 833 small U.S. retail and manufacturing firms.	Regression	Longer CCC is positively associated with Invested Capital and negatively associated with Asset Turnover, ROI, and Net Balance Position.
Farris & Hutchinson (2002)	Snapshot of financial data for several case firms.	Case-examples	Demonstrates the importance of measuring CCC.
Farris & Hutchinson (2003)	1986 and 2001 annual financial data for 5,884 firms across all industries.	Contrasts 1986 and 2001 median CCC values for industries.	Median CCC duration has diminished from 1986 to 2001.
Garcia-Teruel & Martinez-Solano (2007)	Annual financial data for 8,872 small and medium sized firms from 1996 to 2002.	Regression	Shorter CCC, DIO, DPO and DSO are associated with better ROA. DPO loses significance when lagged values are included.
Gill, Biger & Mathur (2010)	88 publicly traded U.S. firms from 2005 to 2007.	Weighted Least Square Regression	DSO is negatively associated with higher profitability and CCC is positively associated with higher profitability.
Hofmann & Kotzab (2010)	Linear Optimization Model	Linear optimization	Reducing CCC for a single firm in a supply chain does not add value to all of the members of the supply chain.
Moss & Stine (1993)	1,717 publically traded U.S. retail firms from 1971 to 1990.	Examined CCC for segments of firms organized by Sales, Assets, and Liquidity ratios.	CCC was shorter for larger firms.
Randall & Farris (2009)	Snapshot of financial data for several case firms.	Case-examples	Provides examples of how a reduced CCC is associated with improved profitability.
Soenen (1993)	Approximately 2,000 publicly traded firms from 20 industries.	Empirical analysis of median CCC and NTC values by quadrant.	CCC varies by industry. Net trade cycle is not strongly associated with corporate profitability.
Stewart (1995)	Hypothetical case example	Case-examples	Proposes that CCC is useful as a benchmarking metric for supply chain firms.

Table 3: Change in cash flow measures[a] (dependent variable: ΔTobin's q).

Independent Variables	**Parameter Estimates (Std. Errors)**
Intercept:	.14 ** (.051)
Quarterly Change in Days of Sales Outstanding (ΔDSO)	
ΔDSO_t (Current Quarter)	-.00011 *** (.00001)
ΔDSO_{t-1} (Previous Quarter)	-.00009 ** (.00003)
ΔDSO_{t-2} (Two Quarters Prior)	-.00019 *** (.00005)
ΔDSO_{t-3} (Three Quarters Prior)	-.00032 ** (.00011)
ΔDSO_{t-4} (Four Quarters Prior)	.00060 (.00057)
Quarterly Change in Days of Inventory Outstanding (ΔDIO)	
ΔDIO_t (Current Quarter)	-.00051 * (.00023)
ΔDIO_{t-1} (Previous Quarter)	-.00033 * (.00017)
ΔDIO_{t-2} (Two Quarters Prior)	-.00007 (.00019)
ΔDIO_{t-3} (Three Quarters Prior)	-.00010 (.00020)
ΔDIO_{t-4} (Four Quarters Prior)	.00035 (.00020)
Quarterly Change in Days of Payables Outstanding (ΔDPO)	
ΔDPO_t (Current Quarter)	-.00017 (.00018)
ΔDPO_{t-1} (Previous Quarter)	-.00019 (.00022)
ΔDPO_{t-2} (Two Quarters Prior)	-.00005 (.00003)
ΔDPO_{t-3} (Three Quarters Prior)	.00000 (.00002)
ΔDPO_{t-4} (Four Quarters Prior)	-.00009 (.00006)
Control Variables	
ln(Quarterly Sales)	-.011 *** (.0028)
Debt to Assets Ratio	.203 *** (.033)
Fit Statistic	
QIC	4206.2

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm
Parameter significance, * ⇒p< 0.05; ** ⇒p < 0.01; *** ⇒p< 0.001

Table 4: Change in quarterly cash flow metrics[a] (dependent variable: ΔTobin's q).

Independent Variables	ΔCCC Parameter Estimates (Std. Errors)	ΔOCC Parameter Estimates (Std. Errors)
Intercept:	.14 ** (.048)	.16 *** (.047)
Quarterly Change in Cash Flow Metric		
ΔCCC_t (Current Quarter)	-.000039 (.000050)	
ΔCCC_{t-1} (Previous Quarter)	-.000043 (.000056)	
ΔCCC_{t-2} (Two Quarters Prior)	-.000049 (.000049)	
ΔCCC_{t-3} (Three Quarters Prior)	-.000077 (.000060)	
ΔCCC_{t-4} (Four Quarters Prior)	.000042 (.000062)	
ΔOCC_t (Current Quarter)		-.00011 *** (.000004)
ΔOCC_{t-1} (Previous Quarter)		-.00011 *** (.000007)
ΔOCC_{t-2} (Two Quarters Prior)		-.00014 *** (.000014)
ΔOCC_{t-3} (Three Quarters Prior)		-.00022 *** (.000029)
ΔOCC_{t-4} (Four Quarters Prior)		.00018 (.000114)
Control Variables		
ln(Quarterly Sales)	-.011 *** (.0027)	-.011 *** (.0026)
Debt to Assets Ratio	.216 *** (.036)	.209 *** (.035)
Fit Statistic		
QIC	4139.3	4038.7

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm
Parameter significance, * $\Rightarrow p< 0.05$; ** $\Rightarrow p < 0.01$; *** $\Rightarrow p< 0.001$

Table 5: Granger causality test of significant cash flow measures (ΔDSO and ΔDIO) and ΔTobin's q[a].

	Test 1: ΔX → ΔY Dependent Variable: Change in Tobin's q [Current Quarter] (ΔTobin's q_t)			**Test 2: ΔY → ΔX Dependent Variable: Change in Component (ΔDSO and ΔDIO) [Current Quarter] (ΔCash Flow $Measure_t$)**			
		Lagged ΔDSO Measurements	**Lagged ΔDIO Measurements**	**Lagged ΔDSO Measurements**		**Lagged ΔDIO Measurements**	
	[Lag ΔY → ΔY]	**[Lag ΔY + Lag ΔX → ΔY]**	**[Lag ΔY + Lag ΔX → ΔY]**	**[Lag ΔX → ΔX]**	**[Lag ΔX + Lag ΔY → ΔX]**	**[Lag ΔX → ΔX]**	**[Lag ΔX + Lag ΔY → ΔX]**
	ΔTobin's q on Lagged ΔTobin's q	**ΔTobin's q on Lagged ΔTobin's q and Lagged ΔDSO**	**ΔTobin's q on Lagged ΔTobin's q and Lagged ΔDIO**	**ΔDSO on Lagged ΔDSO**	**ΔDSO on Lagged ΔTobin's q and Lagged ΔDSO**	**ΔDIO on Lagged ΔDIO**	**ΔDIO on Lagged ΔTobin's q and Lagged ΔDIO**
Independent Variables	**Parameter Est. (Std. Errors)**	**Parameter Est. (Std. Errors)**	**Parameter Est. (Std. Errors)**	**Parameter Est. (Std. Errors)**	**Parameter Est. (Std. Errors)**	**Parameter Est. (Std. Errors)**	**Parameter Est. (Std. Errors)**
Intercept:	-.06 *** (.0064)	-.06 *** (.0080)	-.06 *** (.0080)	.77 (1.01)	2.17 (2.08)	-.89 (.52)	-1.24 * (.51)
ΔTobin's q_{t-1} (Previous Quarter)	-.48 *** (.055)	-.47 *** (.063)	-.46 *** (.063)		57.0 0 (47.07)		-6.27 *** (1.77)
ΔTobin's q_{t-2} (Two Quarters Prior)	-.34 ** (.11)	-.34 ** (.12)	-.34 ** (.12)		-16.10 (16.06)		-4.34 ** (1.51)
ΔTobin's q_{t-3} (Three Quarters Prior)	-.13 *** (.027)	-.10 ** (.032)	-.10 ** (.031)		37.33 (30.44)		-2.54 (1.50)
ΔTobin's q_{t-4} (Four Quarters Prior)	.05 (.086)	.05 (.10)	.05 (.10)		-14.35 (12.21)		.58 (1.31)
ΔCash Flow $Measure_{t-1}$ (Previous Quarter)		.000001 (.00003)	-.00029 * (.00013)	.44 (.25)	.44 (.25)	-.71 *** (.04)	-.71 *** (.04)
ΔCash Flow $Measure_{t-2}$ (Two Quarters Prior)		-.00012 *** (.00003)	-.00017 (.00016)	-1.36 *** (.39)	-1.35 *** (.38)	-.46 *** (.05)	-.46 *** (.05)
ΔCash Flow $Measure_{t-3}$ (Three Quarters Prior)		-.00024 *** (.00006)	-.00012 (.00014)	-1.62 (1.01)	-1.61 (.99)	-.28 *** (.04)	-.28 *** (.04)
ΔCash Flow $Measure_{t-4}$ (Four Quarters Prior)		.00040 (.00038)	.00010 (.00013)	6.88 (5.09)	6.85 (5.03)	-.053 * (.024)	-.054 * (.024)
Fit Statistic							
QIC	5,437.1	4,659.3	4,677.2	6,295,904,309.8	6,198,076,055.4	39,900,802.9	39,573,116.3

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm

Parameter significance, * ⇒$p < 0.05$; ** ⇒$p < 0.01$; *** ⇒$p < 0.001$

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Table 6: Granger causality test of ΔOCC and ΔTobin's q[a].

	Test 1: ΔX → ΔY Dependent Variable: Change in Tobin's q [Current Quarter] (ΔTobin's q_t)		**Test 2: ΔY → ΔX** Dependent Variable: Change in OCC [Current Quarter] (ΔOCC_t)	
	[Lag ΔY → ΔY]	**[Lag ΔY + Lag ΔX → ΔY]**	**[Lag ΔX → ΔX]**	**[Lag ΔX + Lag ΔY → ΔX]**
	ΔTobin's q on Lagged ΔTobin's q	**ΔTobin's q on Lagged ΔTobin's q and Lagged ΔOCC**	**ΔOCC on Lagged ΔOCC**	**ΔOCC on Lagged ΔTobin's q and Lagged ΔOCC**
Independent Variables	**Parameter Estimates (Std. Errors)**	**Parameter Estimates (Std. Errors)**	**Parameter Estimates (Std. Errors)**	**Parameter Estimates (Std. Errors)**
Intercept:	-.063 *** (.006)	-.062 *** (.006)	2.86 (2.18)	4.48 (4.09)
ΔTobin's q_{t-1} (Previous Quarter)	-.48 *** (.055)	-.48 *** (.055)		50.07 (59.68)
ΔTobin's q_{t-2} (Two Quarters Prior)	-.34 ** (.11)	-.34 ** (.11)		-17.58 (19.03)
ΔTobin's q_{t-3} (Three Quarters Prior)	-.13 *** (.027)	-.12 *** (.028)		37.29 (42.75)
ΔTobin's q_{t-4} (Four Quarters Prior)	.052 (.09)	.052 (.09)		-12.16 (14.60)
ΔOCC_{t-1} (Previous Quarter)		-.00003 *** (.00001)	.05 *** (.01)	.06 *** (.01)
ΔOCC_{t-2} (Two Quarters Prior)		-.00006 ** (.00002)	-.76 *** (.04)	-.75 *** (.03)
ΔOCC_{t-3} (Three Quarters Prior)		-.00010 * (.00005)	-.20 * (.09)	-.19 * (.08)
ΔOCC_{t-4} (Four Quarters Prior)		-.00004 (.00002)	-.27 (.15)	-.26 (.15)
Fit Statistic				
QIC	5,437.1	5,433.9	7,755,269,884.2	7,678,742,703.4

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm
Parameter significance, * ⇒$p< 0.05$; ** ⇒$p < 0.01$; *** ⇒$p< 0.001$

APPENDIX: FIXED-EFFECTS ROBUSTNESS ANALYSES

Table A-1: Fixed-Effects analysis of the change in cash flow measures[a] (dependent variable: ΔTobin's q).

Independent Variables	Parameter Estimates (Std. Errors)
Intercept:	.14195 ** (.04966)
Quarterly Change in Days of Sales Outstanding (ΔDSO)	
ΔDSO_t (Current Quarter)	-.00011 *** (.00001)
ΔDSO_{t-1} (Previous Quarter)	-.00009 *** (.00002)
ΔDSO_{t-2} (Two Quarters Prior)	-.00019 *** (.00003)
ΔDSO_{t-3} (Three Quarters Prior)	-.00032 *** (.00005)
ΔDSO_{t-4} (Four Quarters Prior)	.00060 ** (.00021)
Quarterly Change in Days of Inventory Outstanding (ΔDIO)	
ΔDIO_t (Current Quarter)	-.00051 *** (.00010)
ΔDIO_{t-1} (Previous Quarter)	-.00033 ** (.00011)
ΔDIO_{t-2} (Two Quarters Prior)	-.00007 (.00011)
ΔDIO_{t-3} (Three Quarters Prior)	-.00010 (.00011)
ΔDIO_{t-4} (Four Quarters Prior)	.00035 (.00022)
Quarterly Change in Days of Payables Outstanding (ΔDPO)	
ΔDPO_t (Current Quarter)	-.00017 (.00010)
ΔDPO_{t-1} (Previous Quarter)	-.00019 (.00011)
ΔDPO_{t-2} (Two Quarters Prior)	-.00005 (.00003)
ΔDPO_{t-3} (Three Quarters Prior)	.000003 (.00002)
ΔDPO_{t-4} (Four Quarters Prior)	-.00009 (.00005)
Control Variables	
ln(Quarterly Sales)	-.01062 *** (.00274)
Debt to Assets Ratio	.20312 *** (.02882)
Fit Statistic	
AIC	19007.631

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm
Parameter significance, * ⇒p< 0.05; ** ⇒p < 0.01; *** ⇒p< 0.001

Table A-2: Fixed-Effects analysis of the change in quarterly cash flow metrics[a] (dep.var: ΔTobin's q).

Independent Variables	**ΔCCC** **Parameter Estimates (Std. Errors)**	**ΔOCC** **Parameter Estimates (Std. Errors)**
Intercept:	.14259 ** (.05026)	.15682 ** (.05000)
Quarterly Change in Cash Flow Metric		
ΔCCC_t (Current Quarter)	-.000039 (.000023)	
ΔCCC_{t-1} (Previous Quarter)	-.000043 (.000023)	
ΔCCC_{t-2} (Two Quarters Prior)	-.000049 (.000030)	
ΔCCC_{t-3} (Three Quarters Prior)	-.000077 (.000043)	
ΔCCC_{t-4} (Four Quarters Prior)	.000042 (.000022)	
ΔOCC_t (Current Quarter)		.15682 ** (.05000)
ΔOCC_{t-1} (Previous Quarter)		-.000109 *** (.000013)
ΔOCC_{t-2} (Two Quarters Prior)		-.000110 *** (.000015)
ΔOCC_{t-3} (Three Quarters Prior)		-.000143 *** (.000018)
ΔOCC_{t-4} (Four Quarters Prior)		-.000222 *** (.000027)
Control Variables		
ln(Quarterly Sales)	-.010685 *** (.002771)	-.011399 *** (.002756)
Debt to Assets Ratio	.215390 *** (.029129)	.208867 *** (.028986)
Fit Statistic		
AIC	19154.6	19095.3

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm
Parameter significance, * ⇒$p< 0.05$; ** ⇒$p < 0.01$; *** ⇒$p< 0.001$

Table A-3: Fixed-Effects Granger causality test of significant cash flow measures (ΔDSO and ΔDIO) and ΔTobin's q[a].

	Test 1: ΔX → ΔY Dependent Variable: Change in Tobin's q [Current Quarter] (ΔTobin's q_t)			Test 2: ΔY → ΔX Dependent Variable: Change in Component (ΔDSO and ΔDIO) [Current Quarter] (ΔCash Flow $Measure_t$)			
		Lagged ΔDSO Measurements	Lagged ΔDIO Measurements	Lagged ΔDSO Measurements		Lagged ΔDIO Measurements	
	[Lag ΔY → ΔY]	[Lag ΔY + Lag ΔX → ΔY]	[Lag ΔY + Lag ΔX → ΔY]	[Lag ΔX → ΔX]	[Lag ΔX + Lag ΔY → ΔX]	[Lag ΔX → ΔX]	[Lag ΔX + Lag ΔY → ΔX]
	ΔTobin's q on Lagged ΔTobin's q	ΔTobin's q on Lagged ΔTobin's q and Lagged ΔDSO	ΔTobin's q on Lagged ΔTobin's q and Lagged ΔDIO	ΔDSO on Lagged ΔDSO	ΔDSO on Lagged ΔTobin's q and Lagged ΔDSO	ΔDIO on Lagged ΔDIO	ΔDIO on Lagged ΔTobin's q and Lagged ΔDIO
Independent Variables	Parameter Est. (Std. Errors)	Parameter Est. (Std. Errors)	Parameter Est. (Std. Errors)	Parameter Est. (Std. Errors)	Parameter Est. (Std. Errors)	Parameter Est. (Std. Errors)	Parameter Est. (Std. Errors)
Intercept:	-.05405 *** (.00844)	-.05334 *** (.00840)	-.05435 *** (.00842)	1.28646 (2.95992)	3.05041 (3.06217)	-.83999 (.75914)	-1.13778 (.76549)
ΔTobin's q_{t-1} (Previous Quarter)	-.43797 *** (.00933)	-.44026 *** (.00936)	-.43801 *** (.00934)		63.07192 (37.55539)		-.66830 *** (.00964)
ΔTobin's q_{t-2} (Two Quarters Prior)	-.32164 *** (.00996)	-.32385 *** (.01000)	-.32322 *** (.00999)		-12.67491 (7.57398)		-.42344 *** (.01116)
ΔTobin's q_{t-3} (Three Quarters Prior)	-.08887 *** (.01016)	-.09016 *** (.01020)	-.08995 *** (.01018)		38.18823 (20.47520)		-.25345 *** (.01107)
ΔTobin's q_{t-4} (Four Quarters Prior)	.05108 *** (.00964)	.05195 *** (.00963)	.05030 *** (.00965)		-12.39063 (7.20129)		-.04353 *** (.00980)
ΔCash Flow $Measure_{t-1}$ (Previous Quarter)		-.00001 (.00002)	-.00029 ** (.00009)	.19368 *** (.01162)	.19308 *** (.01162)	-.66896 *** (.00963)	-6.31431 *** (.95137)
ΔCash Flow $Measure_{t-2}$ (Two Quarters Prior)		-.00012 *** (.00002)	-.00017 (.00011)	-1.17141 *** (.01435)	-1.16388 *** (.01434)	-.42176 *** (.01116)	-4.09509 *** (.99052)
ΔCash Flow $Measure_{t-3}$ (Three Quarters Prior)		-.00024 *** (.00004)	-.00011 (.00011)	-1.87485 *** (.02953)	-1.86032 *** (.02948)	-.25256 *** (.01108)	-2.26413 * (1.00440)
ΔCash Flow $Measure_{t-4}$ (Four Quarters Prior)		.00040 * (.00017)	.00011 (.00010)	6.72414 *** (.13992)	6.69102 *** (.13946)	-.04236 *** (.00981)	.99056 (.97813)
Fit Statistic							
AIC	18225.8	18191.5	18218.1	149244.4	149166.6	109325.4	109281.3

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm

Parameter significance, * ⇒$p< 0.05$; ** ⇒$p < 0.01$; *** ⇒$p< 0.001$

Table A-4: Granger causality test of ΔOCC and ΔTobin's q[a].

	Test 1: ΔX → ΔY **Dependent Variable: Change in Tobin's q [Current Quarter] (ΔTobin's q_t)**		**Test 2: ΔY → ΔX** **Dependent Variable: Change in OCC [Current Quarter] (ΔOCC_t)**	
	[Lag ΔY → ΔY]	**[Lag ΔY + Lag ΔX → ΔY]**	**[Lag ΔX → ΔX]**	**[Lag ΔX + Lag ΔY → ΔX]**
	ΔTobin's q on Lagged ΔTobin's q	**ΔTobin's q on Lagged ΔTobin's q and Lagged ΔOCC**	**ΔOCC on Lagged ΔOCC**	**ΔOCC on Lagged ΔTobin's q and Lagged ΔOCC**
Independent Variables	**Parameter Estimates (Std. Errors)**	**Parameter Estimates (Std. Errors)**	**Parameter Estimates (Std. Errors)**	**Parameter Estimates (Std. Errors)**
Intercept:	-.05405 *** (.00844)	-.062 *** (.006)	4.74327 (5.07372)	8.05747 (5.14074)
ΔTobin's q_{t-1} (Previous Quarter)	-.43797 *** (.00933)	-.48 *** (.055)		12.35925 (7.94852)
ΔTobin's q_{t-2} (Two Quarters Prior)	-.32164 *** (.00996)	-.34 ** (.11)		10.76549 (7.93458)
ΔTobin's q_{t-3} (Three Quarters Prior)	-.08887 *** (.01016)	-.12 *** (.028)		11.86716 (7.99292)
ΔTobin's q_{t-4} (Four Quarters Prior)	.05108 *** (.00964)	.052 (.09)		3.73158 (8.08210)
ΔOCC_{t-1} (Previous Quarter)		-.00003 *** (.00001)	-.745510 *** (.010424)	-.73228 *** (.01046)
ΔOCC_{t-2} (Two Quarters Prior)		-.00006 ** (.00002)	-.756966 *** (.013365)	-.74622 *** (.01334)
ΔOCC_{t-3} (Three Quarters Prior)		-.00010 * (.00005)	-1.021865 *** (.019879)	-1.00548 *** (.01984)
ΔOCC_{t-4} (Four Quarters Prior)		-.00004 (.00002)	.030886 (.05`6907)	.05216 (.05690)
Fit Statistic				
AIC	18225.8	5,433.9	150937.7	150882.7

[a]n=1,233 Manufacturing Firms, 8 Quarters of Data per Firm
Parameter significance, * ⇒p< 0.05; ** ⇒p < 0.01; *** ⇒p< 0.001