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James R. Kroes
*Boise State University*

Andrew S. Manikas
*University of Louisville*

Thomas F. Gattiker
*Boise State University*

Matthew J. Castel
*Boise State University*

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# The Operational Impacts of Chief Supply Chain Officers in Manufacturing Firms

**James R. Kroes***
Boise State University
College of Business and Economics
Boise, ID, USA
jimkroes@boisestate.edu

**Andrew S. Manikas**
University of Louisville
Management Department
College of Business
Louisville, KY, USA
andrew.manikas@louisville.edu

**Thomas F. Gattiker**
Boise State University
College of Business and Economics
Boise, ID, USA

**Matthew J. Castel**
Boise State University
College of Business and Economics
Boise, ID, USA

**Abstract**

Many firms have elevated their supply chain management decision-making responsibilities through the creation of "Chief Supply Chain Officer" (CSCO) positions. This is widely attributed to the recognition that superior supply chain operations can generate a competitive advantage. Prior studies have found that firms with CSCOs outperform firms without CSCOs along many financial dimensions. However, these prior efforts did not examine the pathways by which these improvements occur. This study addresses this gap in the literature by investigating whether supply chain characteristics of manufacturing firms differ within firms with CSCOs. To explore this, we investigate the relationship between CSCOs and operational dimensions of supply chain performance using data from the ten-year period between 2008 and 2017. We find that the presence of a CSCO in a firm is associated with shorter cash conversion cycles, lower levels of operational slack, and larger buffers of inventory during periods of high market instability.

**Keywords:** Chief Supply Chain Officer, supply chain management, operational performance

## Introduction

Historically, decisions concerning supply chain functions occurred within the middle management layer of firms (Groysberg *et al.* 2011, Essex *et al.* 2018). However, in the last two decades, many firms created "Chief Supply Chain Officer" (CSCO) positions on their organization's top management teams. The creation of these high-level CSCO positions is widely attributed to the recognition that superior supply chain operations can generate a competitive advantage for firms and, consequently, boost performance (Wagner and Kemmerling 2014). Although many companies now employ CSCOs, the position is a new development compared to most other C-suite roles (Kador 2012, University of Tennessee 2019). A search of the popular press and academic publications (utilizing ProQuest) finds that the first identified reference to a "Chief Supply Chain Officer" occurred in 1996 (Thomas 1996) and according to Gartner, the role only began emerging broadly in 2009 (Supply Chain Brain 2014).

A small number of studies have empirically investigated how CSCOs impact their organizations from a variety of perspectives. Based on a sample of 211 North American firms, Wagner and Kemmerling (2014) found that the presence of a CSCO had a negative effect on operating profits, which led the authors to suggest that future research should examine contingency factors. Hendricks *et al.* (2015) found public announcements of the creation of supply chain and operations management executive positions are associated with positive stock market reactions immediately after the announcements. Taking a cue from Wagner and Kemmerling (2014), Roh *et al.* (2016) found that the relationship between ROA and leverage, internationalization and diversification are all positively affected by the presence of a CSCO (however, a significant direct effect was not found).

Taken together, these extant studies provide important insights into how CSCOs impact firm performance; however, the resulting evidence is mixed. This suggests the need for "deeper dives" into how and under what conditions CSCOs are positive difference makers. A commonality among the prior studies is that they examine the relationship between CSCOs and overall firm performance. Our study moves down a level to look at supply chain performance and efficiency. We examine supply chain performance as a whole and then we turn the dial of the microscope further by examining individual components of supply chain performance. In particular, we examine the effect of CSCOs on the cash conversion cycle (*CCC*) and its components, which has been widely utilized as a measure of supply chain performance in prior studies (see Hendricks *et al.* 2009; Modi and Mishra 2011; Kovach *et al.* 2015; Kroes *et al.* 2018). We also examine, the relationship between the presence (or absence) of a CSCO and operational slack and, following Wagner and Kemmerling (2014) and Roh *et al.'s* (2016) lead, we investigate the role of a contingency factor (in this case market instability.) We believe our results help to paint a more complete picture of how and under what conditions CSCO presence improves firm performance.

In the next section, we present a review of relevant literature, which is used to develop our research hypotheses. We then discuss our methodology and results. This is followed by a discussion of our findings and conclusions from the study.

## Theoretical Framework and Hypotheses

### Upper Echelon Theory

Upper Echelon Theory (UET) (Hambrick and Mason 1984) states that the characteristics of the top management team (TMT) determine how the team perceives its environment, which in turn affects the strategic choices the team makes, thus influencing organizational performance. The theory focuses on individual-level characteristics of TMT members; specifically, their backgrounds, including functional expertise and industry experience. UET also focuses on properties of the TMT, such as heterogeneity. More recent research has focused on the effects of the inclusion or exclusion of particular functional roles (e.g. Chief Financial Officer, Chief Operating Officer, Chief Digital Officer) on the TMT (Menz 2012, Kunisch *et al.* 2020). This functional orientation is an important characteristic because it provides a voice on the TMT for the functions that are represented, helping ensure that the functional viewpoints are integrated into strategy determination and decision making (Seidel *et al.* 2019). In addition to this horizontal dynamic, when a function is represented on the TMT, it may increase the likelihood that issues and initiatives that are important to that function are prioritized downward to the middle and lower tiers of the organization (Dubey *et al.* 2018). Hence, the knowledge and functional experience of these top-level managers become the basis for a firm's strategic decision-making (Kumar and Paraskevas 2018).

### CSCOs and Supply Chain Performance

In defining CSCO, we concur with Roh *et al.* (2016, p. 50) who state, that a CSCO is a "TMT-level executive who is explicitly responsible for enterprise-wide supply chain management activities." We also note that supply chain management activities can be distinguished from related activities, such as operations, purchasing and logistics by the following three criteria posited by Mentzer *et al.* (2008): 1) Coordination with suppliers and customers, 2) demand and supply-side matching, and 3) a flow perspective. In line with this, our study examines firms that have incorporated a C-level position specifically designated as a "Chief Supply Chain Officer" into their TMTs. We believe that designating a role with this title represents an overt commitment to the incorporation of supply chain expertise within the TMT, versus instilling supply chain responsibilities into another role (Mentzer *et al.* 2008). As an analogy, creating a Chief Diversity Officer (as opposed to assigning diversity responsibilities to a TMT member with a title such as Chief Human Resources Officer) constitutes a signal about the importance of diversity in an organization (Dobbin *et al.* 2007).

Management affects supply chain performance through many pathways (Mangan and Christopher 2005, Sweeney *et al.* 2018, Chiarini and Brunetti *et al.* 2019). Correspondingly, UET implies that firms attempting to leverage supply chain capabilities to gain a competitive advantage should incorporate leaders with appropriate supply chain skills and experience into the top management team. Accordingly, a TMT-level supply chain executive affects performance through interactions in three realms: Within the TMT, downward within the focal firm, and across the inter-organization linkages between the focal firm and its customers and suppliers.

Within the TMT, CSCOs are likely to be more active participants in their firms' strategic planning processes (Wagner and Kemmerling 2014). By interacting directly with other TMT members, a CSCO can increase this team's understanding of how supply chain capabilities and constraints may benefit the firm (Youn *et al.* 2012). This can translate into better strategic decisions (Hendricks *et al.* 2015) while providing the firm with a better understanding of the supply chain's financial implications (Sanders and Wagner 2011).

Turning from the TMT to activities downward within the firm, CSCOs are responsible for the entirety of a firm's supply chain operations (compared to, for example, Chief Purchasing, Logistics or Operating Officers, who focus on specific activities within supply chains) (Roh *et al.* 2016). A likely operational benefit of a more powerful executive overseeing all SCM activities is a more extensive span of control and, hence, more authority to better align a firm's supply chain activities with the firm's goals (Johnson and Leenders 2008, Fawcett *et al.* 2010a). Roh *et al.* (2016, p. 50) describe this as a responsibility for CSCOs to "develop strategic partnerships with the business units that the supply chain management organization supports." In line with this, Mentzer *et al.* (2008) discuss the example of inventory management as being inherently cross-functional and thus requiring the participation of logistics, sales, marketing, and operations. They go on to assert that initiatives of this type will be more successful under the auspices of a CSCO precisely because of a CSCO's ability to gain the buy-in (or at least the compliance) of all of the functional areas that need to participate. Broadly, the role that a CSCO plays in improving internal supply chain performance is analogous to the role of management in lean improvement efforts; where it has been shown that two keys to success are 1) top management involvement (Prajogo and Cooper 2010) and, relatedly, 2) an organizational structure built to support improvement initiatives (Martinez-Jurado and Moyano-Fuentes 2014).

Finally, at the inter-organization level, programs involving more than one company typically require executive-level involvement in order to initiate and plan the integrated efforts between firms and to potentially oversee their ongoing operation (Roh *et al.* 2016). An executive with end-to-end responsibility (i.e. a CSCO) is best positioned to make initiatives of this type succeed (Mentzer *et al.* 2008).

In the following sections, we introduce our dependent variables and we explain the pathways by which we expect CSCO presence on the TMT to affect each of these variables. Figure 1 presents our conceptual model and hypotheses. The hypotheses are discussed in detail in the following three sub-sections.

------------ Insert Figure 1 approximately here ------------

**CSCOs and the Cash Conversion Cycle**

To examine the relationship between CSCOs and supply chain performance, we must understand what characterizes performance in this context. Sweeney *et al.* (2018, p. 854) state "Managing supply chain processes in a more integrated manner requires that performance measurement is carried out more holistically." The cash conversion cycle (*CCC*) provides the ideal holistic measure since, at a minimum, it requires that the focal firm influence and manage suppliers and customers (in order to manage payables and receivables) in addition to internal operations. At a maximum, truly optimizing the *CCC* requires that the focal firm collaborates with suppliers and customers (as well as others such as logistics providers and financial institutions) (Hofmann and Kotzab 2010, Akgün and Gürünlü 2010, Farris and Hutchison 2002). Put differently, financial supply chain management (FSCM) is a collaborative inter-organizational approach that optimizes all *CCC* aspects (payables, receivables and inventories) across a supply chain involving the focal firm's customers and suppliers (Caniato *et al.* 2016). These practices also require collaboration between the supply chain and finance functions within and across companies (Mathis and Cavinato 2010). Inhibitors of FSCM include intra-organizational issues (e.g. functional silos, culture, etc.) and inter-organizational factors (e.g. process and standards incompatibility, poor inventory visibility, trust, etc.) (Chakuu *et al.* 2019) all of which have a greater probability of being overcome when a single individual on the TMT has end-to-end responsibility for the supply chain.

The relationship between the *CCC* (which is the sum of the days of sales outstanding [*DSO*] and the days of inventory outstanding [*DIO*] minus the days of payables outstanding [*DPO*]) and firm performance has been examined in a variety of SCM contexts (e.g. Moss and Stine 1993, Hendricks *et al.* 2009, Ebben and Johnson 2011, Kroes and Manikas 2014). Specifically, it has been demonstrated that firms with supply chain operations that hold lower inventories, while collecting receivables from customers in shorter time frames and delaying payments to suppliers, are utilizing their cash more efficiently and improving their firm's solvency (Hofmann and Kotzab 2010). Based on the foregoing argument that CSCOs improve supply chain performance we predict that:

> H1: *The presence of a CSCO is associated with a shorter cash conversion cycle (CCC).*

To further investigate, we also individually examine the three components (or "levers") of the *CCC* (i.e., *DSO*, *DIO*, and *DPO*.) Prior research has consistently found that the faster receipt of cash from customers (i.e. a lower *DSO*) benefits a firm by allowing them to reinvest in additional opportunities (Gallinger 1997, Bauer 2007). The linkage between supply chain management inclusion on the TMT and improved receivables performance might not be obvious; however, prior research has illustrated some mechanisms that help explain this relationship. For example, Lo *et al.* (2009) show that ISO 9000 certification efforts, led by senior management, generate operational improvements which result in decreases in the accounts receivable days. Similarly, Hofmann and Zumsteg (2015) demonstrate how supply chain finance solutions, in particular, an accounts receivable platform managed by a financial institution and sponsored by a supplier firm, benefits all firms, but especially the focal firm, who sponsors the program and secures the participation of a critical mass of buyer firms. Endeavors of these types are ideally facilitated by CSCOs because they require high-level inter-functional buy-in within the focal firm (i.e. sales, logistics and finance) and high-level inter-organizational commitment (i.e. between the focal firm and its customers) (Hofmann and Kotzab 2010). By comparison, the relationship between supply chain management effectiveness and inventory performance is accepted in the literature with more clarity; a wealth of research has shown that higher performance supply chains carry lower levels of inventory (Hendricks *et al*. 2009, Modi and Misha 2011, Kovach *et al.* 2015). As mentioned previously, inventory management is inherently a cross-functional activity, which is likely to be more effectively managed when it is overseen holistically by an executive with supply chain expertise (Mentzer *et al.* 2008). Therefore, we predict the following two sub-hypotheses:

> H1a: *The presence of a CSCO is associated with a shorter days of sales outstanding (DSO) period.*

> H1b: *The presence of a CSCO is associated with a shorter days of inventory outstanding (DIO) period.*

By contrast, the conceptual relationship between supply chain effectiveness and payables is open to multiple interpretations. Certainly, lengthening outstanding payables is a part of the supply chain strategy of many companies in order to improve liquidity at suppliers' expense (Stewart 1995, Shumsky and Trentmann 2018). On the other hand, numerous firms recognize the advantages of shortening the payment cycle. These benefits range from improved supplier relationships and early payment discounts (Fawcett *et al.* 2010b) to initiatives aimed at improving supplier liquidity, particularly when larger buyers have cheaper access to capital than their smaller suppliers (Hofmann and Zumsteg 2015). Regardless of whether the focal firm's objective is to increase outstanding payables or decrease them, all of these initiatives involve cross-functional and inter-organizational dynamics and thus we would expect all of them to be facilitated by the presence of a CSCO. Consequently, due to these conflicting views on *DPO*, we propose the following two sub-hypotheses – the first supporting the view that a CSCO will attempt to improve performance by lengthening the *DPO* cycle in an effort to shorten the *CCC*, and the second, which supports the view that a CSCO will shorten the *DPO* period to improve supplier relationships and possibly receive early payment discounts:

> H1c: *The presence of a CSCO is associated with a longer days of payables outstanding (DPO) period.*

> H1c (alternate): *The presence of a CSCO is associated with a shorter days of payables outstanding (DPO) period.*

## **CSCOs and Operational Slack**

The second aspect of supply chain performance we investigate is the level of operational slack present within an organization. Excessive slack is often considered waste and reduced slack has been related to higher performance (Kroes *et al.* 2018). From a supply chain perspective, the two commonly explored dimensions of operational slack are *capacity slack* and *inventory slack* (Kovach *et al.* 2015).

*Capacity slack*, which assesses how efficiently a firm utilizes its assets to generate sales is measured as the ratio of a firm's plant, property, and equipment to its sales (Kovach *et al.* 2015). Reduced levels of *capacity slack* have been linked to lower costs, higher margins, and superior firm performance (Harry and Schroeder 2006). Accordingly, it can be expected that CSCOs will be involved in managing the utilization of production assets and thus, directly influencing their firms' *capacity slack*. Consequently, similar to our first hypothesis, we believe that a CSCO will steer his or her firm to operate as efficiently as possible, therefore we predict that:

H2: *The presence of a CSCO is associated with a lower level of capacity slack.*

Note that in prior studies the term *"inventory slack"* has been used to describe the levels of inventory relative to the costs of sales, which is fundamentally the same inventory measure included in the *CCC* metric (Kroes et al. 2018). Therefore, we do not include a distinct hypothesis concerning *inventory slack*, although we do explore the relationship between CSCOs and *inventory slack* using the individual examination of the *DIO* measure conducted in the analysis of the first hypothesis (specifically H1b).

**CSCOs, Operational Slack, and Market Instability**

UET posits that turbulence, such as high demand instability, moderates the relationship between top management team characteristics and firm performance (Abebe 2010). Specifically, Hambrick and Mason (1984) argue that in unstable environments, greater diversity of experience in the TMT will be associated with higher performance, whereas in stable environments, greater functional diversity leads to diminished performance. In this study's context, we would expect to see this type of relationship manifest itself in how operational slack is managed within firms where CSCOs are present during periods of high demand instability. While reduced levels of slack have generally been linked to improved performance, the dominant thinking in the operations and supply chain field is that increases in uncertainty can be effectively buffered by increasing slack (e.g. Hendricks *et al.* 2009). Specifically, excess operational slack, in the form of additional inventory, can safeguard against the impacts of fluctuating demand (Hendricks *et al.* 2009, Kroes and Manikas 2018). Likewise, excess manufacturing capacity may also be leveraged to respond to demand instability (Manikas and Patel 2016). Supporting this, prior research has demonstrated that higher levels of operational slack in firms have been linked to superior firm performance during periods of high market instability (Kovach *et al.* 2015). A CSCO is likely to add significantly to the board's knowledge and expertise regarding the role of operational slack, especially its contingent nature. Therefore, we expect that firms with CSCOs will make more informed and nuanced strategic decisions regarding operational slack. Hence, we predict that when markets are unstable, CSCOs will steer their firms to carry higher levels of both inventory slack and capacity slack:

H3a: *During periods of high market instability, the presence of a CSCO is associated with increased levels of inventory slack.*

H3b: *During periods of high market instability, the presence of a CSCO is associated with increased levels of capacity slack.*

## Research Methodology

We exclusively examine the manufacturing industry in this study; several factors contributed to this decision: First, manufacturers producing tangible goods require the careful management and coordination of all activities across their supply chains, compared to firms in industries that do not produce physical goods, which presents CSCOs in manufacturing firm with added opportunities to influence operations (Capkun *et al.* 2009). Next, because manufacturers are in the middle of supply chains, they must balance the requirements of both customers and suppliers, with the needs of their firms (Swaminathan *et al.* 1998), again, presenting CSCOs with more occasions to affect their firms.

**Data Sample**

We analyze the impact of CSCOs over the period 2008 through 2017. Two databases, which were matched and merged, were used to build the repeated-measures dataset. Quarterly firm-level financial data was retrieved from the COMPUSTAT database for publicly traded firms operating between January 1, 2008 and December 31, 2017. At the initiation of this study 2017 represented the last complete calendar quarter of available data. The COMPUSTAT sample includes data from publicly traded manufacturing firms operating within the Standard Industry Classification (SIC) two-digit groups 20 to 39. Quarterly data was chosen over annual data to provide more granularity in our analyses with one exception – the number of employees in a firm is only reported in the annual COMPUSTAT data, therefore the end of year number of employees was used for all four quarters within a year. To adjust for differences in fiscal quarter reporting dates among firms, the calendar quarter during which information was released by a firm was used in our analyses.

In order to identify firms with CSCOs, the financial data was matched with information from the BoardEx database for the same ten-year time period. BoardEx contains detailed reporting of the composition of the executive boards within publicly traded firms. BoardEx has been used extensively to evaluate the makeup of top management teams of corporations. In many of these analyses, either the structuration of the TMT (e.g. Hambrick *et al.* 2015), executive counts (e.g. Boone *et al.* 2019), or the position of executives (e.g. Florackis and Sainani 2018, Fu *et al.* 2019, Feng *et al.* 2020, Kunisch *et al.* 2020), have been utilized to explore the effects of top leaders on organizations.

With the concept of a CSCO being relatively new, there is a need to specifically distinguish firms that have incorporated CSCOs into their TMTs. Roles focused on procurement, operations, or logistics individually represent less complete views of the supply chain. This is similar to what Kunisch *et al.* (2020) did with their assessment of Chief Digital Officers (CDO), where they reduced their search terms to "digital". Using this approach, we conducted a case-insensitive Boolean search for the terms "chief", "supply", "chain" and "officer". This process identified 145 firms with CSCOs across all industries. (We also searched for abbreviations such as "SCM" and "S.C.M."; however, these searches did not generate any results.) We then conducted a manual review of all records that included the terms "supply' and "chain" in order to ensure that we were not overlooking any instances of CSCOs. This did not yield any additional instances. Forty-two of the 145 firms were in the manufacturing industry. Within the group of 42 firms, 39 of 42 titles are specified exactly as "Chief Supply Chain Officer". The other three, which we include in our sample, are "Chief Integrated Supply Chain Officer", "Chief Global Supply Chain and Information Technology Officer" and "Chief Manufacturing, Supply Chain and Engineering Officer."

After merging the datasets, several steps were taken to limit the impact of outliers. First, firms were dropped from our sample if they reported information in less than 8 quarters during the study's 10-year time frame. Additionally, small-sized firms, which in manufacturing are typically identified as those with less than 500 employees (Beesley 2016), were removed as smaller firms have been shown to differ when it comes to governance practices (Drempetic *et al.* 2019), which limits the generalizability of insights gleaned from these firms. Finally, the variables of interest were winsorized at the 1% and 99% level to remove outliers (Hendricks and Singhal 2005). However, we should note that no firms employing CSCOs were included in those removed during the small firm removal and winsorizing processes.

The sample includes 56,898 observations over the ten-year study window from 1,796 firms. Of these, 42 firms (responsible for 1,559 observations), in 14 of the 20 SIC two-digit groups, had a CSCO present during some portion of the sample period. For our analyses, we only include the 14 SIC two-digit groups that include firms with CSCOs. This results in a final sample of 39,428 observations across 1,431 firms. To facilitate the comparison between firms with and without CSCOs, the descriptive statistics for the variables of interest are presented separately for these two groups of firms, respectively, in Tables 1 and 2. The correlations of the variables in the dataset are presented in Table 3.

------------ Insert Tables 1 and 2 approximately here ------------

------------ Insert Table 3 approximately here ------------

**<u>Sample Characteristics</u>**

An inspection of our data highlights several points of interest. As shown in Figure 2, the cumulative number of CSCOs present in firms in a single quarter grew from 3 to 35, reflecting this study's underlying theme that manufacturers are increasingly recognizing the value of these officers. Comparing the firms in our sample that have a CSCO (Table 1) with those that do not (Table 2), we see that the average firm size, measured by total assets are similar for the two groups ($9.1 billion vs. $10.1 billion, respectively.) Relatedly, the average quarterly sales for the two groups are comparable; averaging $2.2 billion for firms with CSCOs and $2.0 billion for firms without CSCOs.

------------ Insert Figure 2 approximately here ------------

**Independent Variables**

Two independent variables are included in our model:

***CSCO Presence*:** is a binary indicator variable used to denote any quarter during which a firm has a CSCO on their board (i.e., *CSCO presence* = 1 when a CSCO is employed, 0 otherwise.) The data provided by BoardEx includes the specific starting and ending dates of a CSCO's tenure – which was used to identify the calendar quarters during which firms employed CSCOs.

***Market Instability*:** To evaluate the effect of unstable demand on the relationship between operational slack and performance, we include a measure of market instability in our models. The *market instability* measure, also utilized in Kovach *et al.* (2015), evaluates the volatility of sales within a two-digit SIC group. For a quarter, the level of market instability is calculated by comparing the minimum and maximum seasonal indices for a two-digit SIC industry group over the prior 20 quarters. The seasonal indices are calculated using the ARIMA X-12 Seasonal Adjustment Program which computes a sales forecast, adjusted for seasonality, for each two-digit SIC group (Findley *et al.* 1998). The interaction effect between the presence of a CSCO and market instability will be assessed to examine Hypotheses 3a and 3b.

**Dependent Variables**

We utilize five measures to assess if the supply chains among firms with CSCOs exhibit different characteristics than those within firms without CSCOs. As discussed above, the first four supply chain performance measures are the three components of the cash conversion cycle (*CCC*) and then the *CCC* itself. The fifth supply chain performance measure tested is *capacity slack*. These measures and their computations are described below in detail.

***Days of Sales Outstanding* (*DSO*):** computed for firm *i* during quarter *t* as the end of quarter accounts receivables divided by the quarterly sales multiplied by 91 days (i.e. three months) (Zeidan and Shapir 2017):

$$DSO_{it} = \frac{(Accounts\ Receivable_{it})}{SALES_{it}}\ x\ 91\ days$$

A shorter (lower) *DSO* period implies that a firm collects payments from customers more quickly.

***Days of Inventory Outstanding* (*DIO*):** calculated for firm *i* during quarter *t* as the firm's end of quarter total inventory ($INV_{it}$) divided by the quarterly cost of goods sold ($COGS_{it}$) multiplied by 91 days (Zeidan and Shapir 2017). A variation of this measure, unadjusted for days, has been used as a measure of *inventory slack* in prior studies (Kovach *et al.* 2015):

$$DIO_{it} = \frac{Inventory_{it}}{COGS_{it}}\ x\ 91\ days$$

A shorter (lower) *DIO* period indicates that a firm is holding less inventory – this measure has been used as a proxy for one aspect of firm leanness in the literature (Hines and Rich 1997). When viewed as a measure of slack, it has been theorized that firms with a longer (higher) *DIO* are better able to respond to variations in demand (Kovach *et al.* 2015).

***Days of Payables Outstanding* (*DPO*):** computed for firm *i* during quarter *t* as the firm's accounts payable divided by the sum of the quarterly cost of goods, multiplied by 91 days (Zeidan and Shapir 2017):

$$DPO_{it} = \frac{Accounts\ Payable_{it}}{COGS_{it}}\ x\ 91\ days$$

A longer (higher) *DPO* period signifies that a firm pays its suppliers less quickly.

***Cash Conversion Cycle* (*CCC*):** for firm *i* during quarter *t*, the *CCC* is the sum of the $DSO_{it}$ and $DIO_{it}$ minus the $DPO_{it}$ (Zeidan and Shapir 2017). The *CCC*, referred to frequently also as the cash-to-cash cycle in the literature, is calculated as:

$$CCC_{it} = DSO_{it} + DIO_{it} - DPO_{it}$$

A shorter (lower) *CCC* period indicates that a firm is turning its cash over more rapidly; that is, the time period from when purchases (investments into materials, etc.) are made from suppliers to when they become products and generate revenue is shorter for firms with lower *CCCs* (Stewart 1995).

***Capacity Slack* (*CS*):** is computed for firm *i* during quarter *t* as the firm's net property, plant, and equipment value divided by the quarterly sales:

$$CS_{it} = \frac{Property, Plant, and\ Equipment_{it}}{SALES_{it}}\ x\ 100$$

*Capacity slack* has been used as both a measure of leanness (Kroes *et al.* 2018) and as an indicator of a firm's capability to respond to variations in demand (Kovach *et al.* 2015). From a leanness perspective, a lower *capacity slack* level suggests that a firm is utilizing resources more efficiently, while from a slack viewpoint, higher *capacity slack* intimates that a firm has more flexibility to address changes in demand.

## Control Variables

We include three control measures in our model. First, to control for differences in firm size, which has been linked to differences in performance - particularly in environments when demand is unstable (Kovach *et al.* 2015), we include the natural log of total assets. The natural log was used because the total assets data in our sample are non-linearly related to our dependent measures. Next, we include a measurement of leverage to control for the level of debt within firms, since debt loading has been linked to differences in shareholder value (McConnell and Servaes 1990). In a supply chain context, more leveraged firms might have less flexibility to adjust their cash flows due to required debt payment obligations (Capon *et al.* 1990). Explicitly, *leverage* is calculated as:

$$Leverage_{it} = \frac{Long\ Term\ Debt_{it}}{Total\ Assets_{it}}$$

Finally, we include a binary indicator variable to control for the impact of the December 2007 to June 2009 economic recession on the firms in the sample. The control variable has a value of one for calendar quarters during the recession and a value of zero for all other quarters.

## Model Specification

In our analysis, we utilize a mixed-model methodology that accounts for the panel nature of the dataset while controlling for differences across the industry groups included in the sample. This methodology has been used in previous analyses of panel datasets with nested industry groupings (Modi and Mishra 2011; Wani *et al.* 2018). The general form of our mixed model is as follows:

$$Y_{ijt} = \pi_{0j} + \pi_{xj}(x_{ijt}) + \beta_k(w_t) + \beta_l(z_{ijt}) + \lambda_t + \theta_i + \varepsilon_{ijt}$$

$$\pi_{0j} = \alpha_0 + \mu_{0j}$$

$$\pi_{xj} = B_x + \mu_{xj}$$

where, for a firm *i* in industry *j* during quarter *t*:

$Y_{ijt}$ is the dependent variable (*CCC, capacity slack,* etc.)

$\alpha_0$ is the intercept term indicating the overall fixed effects

$\mu_{0j}$ represents the unobserved industry level random effects

$B_x$ represents the firm-level fixed effects

$\mu_{xj}$ represents the unobserved random heterogeneity

$x_{ijt}$ is the vector of time-varying independent variables (*CSCO Presence and Market Instability*)

$w_t$ is the industry invariant control variable (*Recession*)

$z_{ijt}$ is the vector of time-variant control variables (*ln(Assets) and Leverage*)

$\lambda_t$ represents the unobserved time-specific fixed effects

$\theta_i$ represents the unobserved firm-specific fixed effects

$\varepsilon_{ijt}$ is the random error

## Results

The results of our analyses and a summary of our hypothesis tests are presented in Tables 4, 5, and 6, respectively. STATA 15 was utilized to analyze the models and test the hypotheses. For all of the models, the F-tests were significant; reinforcing the use of a time-series panel model versus a pooled ordinary least squares approach (Baum 2001). An additional consideration in time-series panel model analyses is if multicollinearity is present and influencing the results. To test for this, Variance Inflation Factor (VIF) tests were performed and the VIF scores for all of the models are less than 2.0, well below the recommended maximum allowable value of 10 (Cohen *et al.* 2003).

The model specified in the prior section was utilized to evaluate H1, H1a, H1b, and H2. Table 4 presents the results for the first two hypotheses. Model 1 examines the *CCC*, while Models 2 through 4 examine its components (*DSO*, *DIO*, and *DPO*). The results of Model 1's analysis show that the presence of a CSCO is significantly associated with a shorter *CCC* ($\pi = -12.20$, $p<0.01$), supporting the overall Hypothesis 1. Additionally, the *DSO* ($\pi = -3.356$, $p<0.01$) and *DIO* ($\pi = -9.843$, $p<0.01$) components of the *CCC* are significantly shorter when a firm employs a CSCO – supporting conventional cash flow management theory (sub-Hypotheses 1a and 1b). However, the analysis does not find a significant relationship between the presence of a CSCO and *DPO* ($\pi = -0.852$, $p>0.10$), which indicates a lack of support for both H1c and the counter hypothesis H1c (alternate). The fifth model, which investigates *capacity slack*, finds that the presence of a CSCO is significantly related to lower levels level of *capacity slack* ($\pi = -36.19$, $p<0.01$) – supporting Hypothesis 2.

------------ Insert Table 4 approximately here ------------

A variation of the model, incorporating an interaction between the presence of a CSCO and market instability, is utilized to analyze Hypotheses 3a and 3b. The results of this analysis are shown in Table 5. Hypothesis 3a is moderately supported by Model 6, which indicates that firms with a CSCO have more *inventory slack* (i.e., longer *DIO* periods) during periods of higher market instability ($\pi = 6.153$, $p<0.10$). In contrast, we do not find support for Hypothesis 3b as the analysis does not find that firms with CSCOs have significantly higher levels of *capacity slack* during periods of high market instability ($\pi = 3.469$, $p>0.10$).

----------- Insert Tables 5 and 6 approximately here ------------

## Discussion and Conclusions

A key contribution of this study is the corroboration of the premise that firms with CSCOs will have higher performance supply chains. Specifically, we find strong evidence that the supply chains among firms with CSCOs typically operate following many of the tenets of effective supply chain management – that is, firms with CSCOs have shorter cash cycles, less inventory, lower levels of *capacity slack*, and they have greater inventory flexibility during periods of high market instability.

The nature of this analysis (i.e., the use of a binary variable to indicate the presence of a CSCO) facilitates the comparison of firms with and without CSCOs. From Table 4, it is demonstrated that firms with CSCOs, on average, have *CCCs* approximately 12.2 days shorter than firms without CSCOs. Examining the three components of *CCC*, we observe that the *DSO* and *DIO* are, respectively, 3.4 and 9.8 days shorter and the *DPO* is approximately 0.9 days shorter for firms with CSCOs. The findings also show that firms with CSCOs have about 36% lower levels of *capacity slack*. Taken together, these results help quantify the supply chain performance differences within firms employing CSCOs.

**Temporal Changes in Supply Chain Performance**

This study's findings have extended our understanding of the relationship between CSCOs and changes in supply chain performance; however, how this relationship evolves over time is an important additional question. Such a temporal examination will further illuminate the impacts of CSCOs since the actions of managers have been shown to change over time, primarily because the time-horizons over which returns are generated by managerial initiatives can vary extensively (Souder and Bromiley 2012).

In the context of this study, two alternative theories on the impact of a newly created CSCO position on a firm's supply chain over time can be postulated: First, literature relating to lean theory suggests that a new focus on improving supply chain performance will quickly generate high returns as there are likely "low-hanging fruit" projects that can be accomplished quickly without extensive efforts (Mader 2008). Supporting this, Reilly *et al.* (2016, p. 1185) emphasize that "…managers regularly make short-term-focused choices, no doubt as a result of the immediate benefits available." However, as these types of short time-horizon activities are completed, future projects (often requiring greater effort levels and lengthier timelines) commonly generate lower returns. In these circumstances, one would expect to see immediate improvements in supply chain performance with diminishing returns over the tenure of a CSCO (Mader 2008). Alternatively, other literature shows that longer-tenured executives accumulate knowledge that helps them to have a better understanding of their firms and the environments in which they operate (Simsek 2007). Thus, in this environment, it may be expected that there will be increasing performance improvements as the tenure of a CSCO progresses.

To examine this issue, we conduct a post hoc analysis in which we replace the binary CSCO indicator variable with an integer representing the number of quarters that a firm has employed a CSCO on their management team (*CSCO tenure*). The results of this analysis, presented in Table 7, provide a view of how the differences in supply chain performance between firms with and without CSCOs change as the tenure of a CSCO position increases.

The first five models analyzed (Models 8 through 12) investigate the *CCC*, its components, and *capacity slack*. The results show that as the length of time over which firms employ CSCOs increases, the superior performance advantage exhibited by these firms also increases. Specifically, for firms with CSCOs, the differences in the *CCC* and *capacity slack* between firms with and without CSCOs widen significantly ($p < 0.01$) over time (i.e., the significant, negative *CCC* and *capacity slack* coefficients indicate that both performance measures improve significantly over time in firms with CSCOs compared to firms without CSCOs.) Further, the examination of the three components of *CCC* shows that the performance gaps for *DIO* and *DPO* both grow larger over time ($p < 0.01$); though, *DSO* does not change significantly over time. These findings, which align directionally with traditional supply chain theory, provide additional insight into the positive association between CSCOs and supply chain performance. Nonetheless, these results assume a linear change over time for the variables of interest, when, in reality, the underlying relationship may be more complex (Isaksson and Seifert 2014). To address this shortcoming, we evaluate the nature of the relationship between CSCOs' tenure and performance by analyzing the square of the *CSCO tenure* integer variable using polynomial regression. This additional set of tests can determine if the relationships are linear or if they follow a more complex quadratic form (e.g. diminishing or increasing returns.) The results of this analysis, shown in Models 13 to 16, establish that the squared term is not significant for *CCC*, indicating a linear relationship, but that the term is significant and positive for *DIO* (*moderately,* $p < 0.10$), *DPO* ($p < 0.01$) and *capacity slack* ($p < 0.01$). This indicates that the relationships between CSCO tenure and changes in these three measures are convex. Figure 3 (*DIO* and *DPO*) and Figure 4 (*capacity slack*) show the nature of the relative changes in *DIO*, *DPO,* and c*apacity slack* for firms with CSCOs over a 20-quarter time frame. This time period was selected as the average CSCO tenure in our sample is approximately 13 quarters, and projections considerably beyond that point are apt to be spurious. Over this five-year window, it is observed that the differences in *DIO* and *capacity slack* between firms with and without CSCOs both grow wider with diminishing returns. This finding corresponds to the prediction that CSCOs appear to generate positive improvements for these two measures early in their tenures and that the magnitude of the improvements diminishes over time. *DPO* exhibits a different pattern during the tenure of a CSCO; initially, there is a slight decrease in the difference between firms with and without CSCOs, which transitions to a progressively positive increasing gap over the time window. This result is consistent with the second proposed relationship, which envisages that improvements will increase as a CSCO garners more experience in the role. Taken in concert with our overall observation that firms with CSCOs exhibit superior performance, these additional findings provide added support for the assertion that CSCOs do have positive impacts on firms, which increases as the CSCO position becomes more established.

------------ Insert Table 7 approximately here ------------

------------ Insert Figures 3 and 4 approximately here ------------

## Theoretical Contribution

This effort also has several primary theoretical contributions. UET research has identified that there is a need for expanding the understanding of how functional members of a TMT influence function-specific outcomes and how these changes occur over time (Menz 2012). While most executive-level managers, such as the CEO or COO, tend to focus within the organization, the CSCO is unique because they have broad responsibilities both within the firm and across its supply chain – i.e. with suppliers and customers (Mentzer *et al.* 2008). As recognized by Roh *et al.* (2016, p. 60), "… CSCOs are a critical new element in Supply Chain Management, meriting further study." In line with that recommendation, our study extends the current body of literature exploring the CSCO position by tying this role to actual operational outcomes. Additionally, our focus exclusively on CSCOs, differentiates this study from similar efforts which examined a broader range of supply chain related positions. While the findings supporting the propositions that CSCOs have positive impacts on firm's supply chains are not unexpected, we believe that research like ours, which links specific functional management roles to operational performance outcomes can provide insight into the value of many management positions – especially emerging roles. Additionally, we believe that the post hoc temporal analysis highlights that the outcomes of managerial efforts are complicated phenomena which cannot always be explained by simple linear relationships.

## Managerial Implications

This study's key finding, that firms with CSCOs typically have more efficient, higher-performing supply chains, supports the prediction that CSCOs will influence their firms to strategically consider the competitive benefits of improved supply chain management and enact operational policies aligned with that objective. While previous studies have shown that more efficiently managed supply chains (i.e., those with lower inventory levels, less *capacity slack*, etc.) tend to exhibit better performance (see Hendricks *et al.* 2009, Modi and Mishra 2011, Kovach *et al.* 2015, Kroes *et al.* 2018), a unique contribution of this study is that it provides evidence linking better performance along these operational dimensions with the presence of a C-level executive focused on supply chain management

From a managerial viewpoint, the assessment of the individual components of the *CCC* provides further insights. The three components of the *CCC* (*DSO*, *DIO*, and *DPO*) represent operational levers that a CSCO can manipulate to improve a firm's cash flow management. The finding that firms with CSCOs have lower *DSO* and *DIO* levels gives an indication that these firms may be using these two levers to improve performance. Although some cash flow management experts advocate for a longer *DPO* period because of the associated liquidity improvements (Stewart 1995), the lack of significance between a CSCO being present and *DPO* is possibly an indicator that CSCOs understand the practical limits of using this lever to improve liquidity. This is supported by prior research that has shown that the benefits of a longer payables cycle are often outweighed by the negative impacts on supplier relationships (Hofmann and Kotzab 2010). Alternatively, these results might be evidence that there is a more complex relationship, where an optimal *DPO* period might balance the trade-offs of early and delayed supplier payments – the examination of which would be an interesting extension to this research.

Similarly, the finding that firms with CSCOs carry more inventory during periods of high market instability (which provides greater flexibility) demonstrates the value of having supply chain "know-how" within an influential role in a firm. Contrasting this finding, the lack of support for the proposition that firms with CSCOs will have more *capacity slack* during periods of instability might be explained by the difference between *inventory slack* and *capacity slack*. Manikas (2017) noted that inventory levels can be adjusted in the short-term while capacity can be added only in the long-term. That is, inventory levels, in the form of materials or finished goods, can be increased relatively easily through additional production operations (e.g. larger orders from suppliers, overtime production, etc.). Conversely, *capacity slack* consists of physical assets (facilities, production equipment, etc.) that cannot be acquired as readily. Further, this *capacity slack* also results in higher opportunity costs because capital assets are allocated to non-realized demand (Manikas and Patel 2016).

**Limitations and Future Research**

There are several limitations to this study, some of which can be addressed through follow on efforts. A key limitation is our focus on the manufacturing industry, which possibly constrains the generalizability of our findings. A wider study, across more industries, would allow us to more confidently assess the value of CSCOs in a broader context. Additionally, our dataset includes 42 manufacturing firms only that have incorporated CSCOs in their management teams - which is indicative of the newness of this role within firms. With the relative newness of the CSCO position, there are questions related to whether these performance advantages can be maintained as competitors of these firms begin to integrate CSCOs into their leadership teams. This suggests that replication of this study at a future date might be justified to confirm our findings.

Further, the dataset used in our study is for firms with more than 500 employees that are publicly traded on U.S. stock markets. We cannot assume generalizability to private firms, nor those not traded on U.S. stock markets. Similarly, while we exclude smaller firms, an extension of this study focused on these firms may provide additional value as prior literature has indicated that while smaller firms may lack the resources found in larger firms, they often can more quickly adapt their supply chain operations to changing conditions (Sánchez and Pérez 2005). Finally, this study does not investigate differences between CSCOs across factors such as compensation, experience, and gender. A detailed analysis exploring the links between these CSCO related factors and operational and firm performance would serve to further elucidate our understanding of the importance of CSCOs to firms.

## Tables and Figures

**Table 1 (a).** Descriptive statistics of firms with Chief Supply Chain Officers by Two-Digit SIC Code

| 2-digit SIC | Industry Title | # of Firms | # of Obs. | DSO (Days) | DIO (Days) | DPO (Days) | CCC (Days) | Capacity Slack |
|---|---|---|---|---|---|---|---|---|
| | | | | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| 20 | Food and Kindred Products | 11 | 424 | 38.50(19.69) | 63.39(30.93) | 47.78(36.97) | 54.78(44.66) | 91.11(44.81) |
| 21 | Tobacco Products | 0 | 0 | - | - | - | - | - |
| 22 | Textile Mill Products | 0 | 0 | - | - | - | - | - |
| 23 | Apparel, Finished Products from Fabrics and Similar Materials | 6 | 222 | 37.69(9.38) | 124.82(36.49) | 45.81(13.61) | 118.15(35.05) | 37.58(12.84) |
| 24 | Lumber and Wood Products, except Furniture | 0 | | | | | | |
| 25 | Furniture and Fixtures | 1 | 40 | 42.50(6.95) | 68.03(5.68) | 21.35(1.92) | 89.17(7.63) | 43.59(5.94) |
| 26 | Paper and Allied Products | 1 | 40 | 46.07(1.74) | 64.35(4.61) | 68.81(13.38) | 41.12(18.07) | 158.05(5.86) |
| 27 | Printing, Publishing and Allied Industries | 0 | 0 | - | - | | - | - |
| 28 | Chemicals and Allied Products | 5 | 183 | 47.69(15.08) | 125.22(60.85) | 57.47(23.74) | 116.37(61.38) | 104.42(61.46) |
| 29 | Petroleum Refining and Related Industries | 0 | 0 | - | - | | - | - |
| 30 | Rubber and Miscellaneous Plastic Products | 1 | 40 | 60.25(10.62) | 65.67(12.44) | 49.99(25.71) | 74.94(21.26) | 76.38(16.75) |
| 31 | Leather and Leather Products | 1 | 18 | 35.84(4.23) | 58.48(7.75) | 63.38(8.39) | 29.71(15.08) | 45.81(8.51) |
| 32 | Stone, Clay, Glass, and Concrete Products | 1 | 40 | 42.84(3.88) | 106.66(10.89) | 39.10(5.91) | 110.44(11.85) | 137.09(17.81) |
| 33 | Primary Metal Industries | 2 | 80 | 60.85(14.80) | 52.56(9.70) | 49.56(10.68) | 63.57(24.64) | 138.46(28.21) |
| 34 | Fabricated Metal Products, except Machinery and Transportation Equipment | 0 | 0 | - | - | - | - | - |
| 35 | Industrial and Commercial Machinery and Computer Equipment | 3 | 114 | 53.29(16.23) | 68.98(29.71) | 57.25(23.76) | 64.97(36.04) | 45.77(17.24) |
| 36 | Electronic and other Electrical Equipment and Components, except Computer Equipment | 5 | 158 | 52.61(16.22) | 91.36(39.87) | 60.26(12.56) | 83.94(61.32) | 59.29(28.11) |
| 37 | Transportation Equipment | 1 | 40 | 61.97(12.73) | 44.98(5.22) | 33.90(2.98) | 73.15(13.87) | 61.55(12.46) |
| 38 | Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, Optical Goods; Watches and Clocks | 2 | 80 | 56.98(4.82) | 130.30(15.77) | 86.44(56.16) | 103.82(50.58) | 65.27(8.86) |
| 39 | Miscellaneous Manufacturing Industries | 2 | 80 | 70.08(13.19) | 94.71(25.38) | 60.05(17.78) | 106.41(33.92) | 45.04(15.65) |
| | Total / Average | 42 | 1559 | 47.17(17.70) | 87.99(44.46) | 52.72(29.42) | 83.17(50.77) | 77.72(47.72) |

**Table 1 (b).** Descriptive statistics of firms with Chief Supply Chain Officers by Two-Digit SIC Code

| 2-digit SIC | Industry Title | Market Instability | Leverage | Quarterly Sales ($MM) | Total Assets ($MM) |
|---|---|---|---|---|---|
| | | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| 20 | Food and Kindred Products | 1.77(0.21) | 0.29(0.12) | 2155.90(2391.65) | 8153.97(6983.59) |
| 21 | Tobacco Products | - | - | - | - |
| 22 | Textile Mill Products | - | - | - | - |
| 23 | Apparel, Finished Products from Fabrics and Similar Materials | 2.32(0.23) | 0.31(0.17) | 951.63(559.18) | 3451.28(3040.69) |
| 24 | Lumber and Wood Products, except Furniture | | | | |
| 25 | Furniture and Fixtures | 1.35(1.22) | 0.04(0.05) | 336.47(41.48) | 716.25(100.64) |
| 26 | Paper and Allied Products | 0.49(0.08) | 0.32(0.08) | 4903.90(286.20) | 17851.35(2088.90) |
| 27 | Printing, Publishing and Allied Industries | - | - | - | - |
| 28 | Chemicals and Allied Products | 1.25(0.10) | 0.45(0.40) | 1337.35(1004.89) | 6875.14(6126.57) |
| 29 | Petroleum Refining and Related Industries | - | - | - | - |
| 30 | Rubber and Miscellaneous Plastic Products | 0.49(0.12) | 0.42(0.12) | 1448.06(392.57) | 7307.05(1910.04) |
| 31 | Leather and Leather Products | 0.82(0.08) | 0.00(0.00) | 114.06(11.55) | 280.18(34.13) |
| 32 | Stone, Clay, Glass, and Concrete Products | 2.90(0.13) | 0.55(0.05) | 202.43(17.09) | 811.84(39.07) |
| 33 | Primary Metal Industries | 1.61(0.63) | 0.38(0.11) | 1600.41(985.71) | 5710.61(2978.28) |
| 34 | Fabricated Metal Products, except Machinery and Transportation Equipment | - | - | - | - |
| 35 | Industrial and Commercial Machinery and Computer Equipment | 0.70(0.17) | 0.28(0.21) | 9397.86(11962.58) | 35598.94(47350.75) |
| 36 | Electronic and other Electrical Equipment and Components, except Computer Equipment | 0.81(0.23) | 0.19(0.14) | 2357.49(1649.72) | 8437.18(7039.77) |
| 37 | Transportation Equipment | 0.75(0.25) | 0.12(0.10) | 646.00(127.16) | 2213.87(652.95) |
| 38 | Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, Optical Goods; Watches and Clocks | 0.48(0.10) | 0.32(0.11) | 1404.14(924.26) | 11989.59(8758.72) |
| 39 | Miscellaneous Manufacturing Industries | 1.98(0.31) | 0.27(0.08) | 1627.36(708.75) | 8645.56(7937.36) |
| | Total / Average | 1.46(0.71) | 0.30(0.21) | 2237.11(4146.91) | 9079.60(16187.62) |

**Table 2 (a).** Descriptive statistics of firms without Chief Supply Chain Officers by Two-Digit SIC Code.

| 2-digit SIC | Industry Title | # of Firms | # of Obs. | DSO (Days) | DIO (Days) | DPO (Days) | CCC (Days) | Capacity Slack |
|---|---|---|---|---|---|---|---|---|
| | | | | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| 20 | Food and Kindred Products | 131 | 4206 | 39.12(24.24) | 79.67(64.45) | 50.85(39.38) | 64.51(68.64) | 118.15(85.09) |
| 21 | Tobacco Products | 6 | 227 | 27.15(17.30) | 152.97(113.06) | 25.51(17.15) | 219.25(117.14) | 52.32(26.15) |
| 22 | Textile Mill Products | 9 | 316 | 52.04(17.15) | 97.71(39.82) | 37.99(20.24) | 111.59(44.85) | 112.84(63.10) |
| 23 | Apparel, Finished Products from Fabrics and Similar Materials | 41 | 1382 | 46.09(25.11) | 124.45(57.83) | 48.27(25.37) | 121.45(51.17) | 61.39(41.51) |
| 24 | Lumber and Wood Products, except Furniture | 32 | 1028 | 34.61(21.07) | 59.68(46.55) | 34.17(25.72) | 59.69(53.44) | 176.72(157.08) |
| 25 | Furniture and Fixtures | 25 | 898 | 48.21(20.20) | 87.47(68.50) | 49.14(23.67) | 86.53(72.02) | 66.35(41.71) |
| 26 | Paper and Allied Products | 58 | 1951 | 49.89(22.05) | 64.28(31.23) | 47.31(20.61) | 65.80(33.98) | 197.98(117.57) |
| 27 | Printing, Publishing and Allied Industries | 54 | 1630 | 51.72(18.88) | 43.04(41.82) | 41.64(25.62) | 53.70(48.10) | 83.30(54.07) |
| 28 | Chemicals and Allied Products | 254 | 7669 | 62.20(28.63) | 124.52(82.68) | 66.58(42.52) | 117.93(82.18) | 133.08(103.30) |
| 29 | Petroleum Refining and Related Industries | 45 | 1569 | 36.66(24.35) | 34.98(18.82) | 48.90(27.59) | 23.23(29.04) | 225.18(179.95) |
| 30 | Rubber and Miscellaneous Plastic Products | 40 | 1100 | 54.01(16.65) | 72.65(30.76) | 44.06(16.18) | 82.11(31.85) | 99.08(49.57) |
| 31 | Leather and Leather Products | 14 | 445 | 44.83(20.49) | 129.37(53.77) | 48.29(22.53) | 126.72(61.76) | 39.68(22.38) |
| 32 | Stone, Clay, Glass, and Concrete Products | 29 | 873 | 55.41(29.02) | 86.57(52.13) | 48.80(31.80) | 94.46(58.07) | 240.77(145.49) |
| 33 | Primary Metal Industries | 78 | 2363 | 49.91(21.53) | 88.36(55.39) | 39.98(22.69) | 97.95(58.39) | 168.61(118.46) |
| 34 | Fabricated Metal Products, except Machinery and Transportation Equipment | 65 | 2108 | 63.28(27.60) | 93.18(59.62) | 46.65(21.20) | 108.46(64.51) | 88.00(45.26) |
| 35 | Industrial and Commercial Machinery and Computer Equipment | 223 | 7005 | 67.70(28.14) | 102.24(60.56) | 55.84(27.92) | 112.73(71.05) | 74.84(63.25) |
| 36 | Electronic and other Electrical Equipment and Components, except Computer Equipment | 313 | 9901 | 63.41(26.51) | 94.90(51.24) | 61.83(32.07) | 96.13(60.32) | 104.42(110.16) |
| 37 | Transportation Equipment | 133 | 4419 | 63.71(37.50) | 76.52(49.68) | 51.83(27.28) | 89.89(58.38) | 95.93(78.75) |
| 38 | Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, Optical Goods; Watches and Clocks | 168 | 5268 | 65.87(22.27) | 143.29(81.22) | 53.44(29.28) | 156.80(78.52) | 70.18(47.34) |
| 39 | Miscellaneous Manufacturing Industries | 36 | 981 | 66.21(30.74) | 111.44(61.58) | 58.93(33.04) | 120.40(70.93) | 62.56(60.28) |
| | Total / Average | 1754 | 55339 | 58.46(28.34) | 97.65(66.57) | 54.36(32.06) | 101.31(71.62) | 109.52(101.15) |

**Table 2 (b).** Descriptive statistics of firms without Chief Supply Chain Officers by Two-Digit SIC Code.

| 2-digit SIC | Industry Title | Market Instability | Leverage | Quarterly Sales ($MM) | Total Assets ($MM) |
|---|---|---|---|---|---|
| | | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| 20 | Food and Kindred Products | 1.77(0.21) | 0.23(0.18) | 2145.94(4629.73) | 9691.62(20611.42) |
| 21 | Tobacco Products | 0.83(0.41) | 0.41(0.23) | 5407.69(3619.05) | 31232.72(19351.76) |
| 22 | Textile Mill Products | 0.19(0.04) | 0.28(0.19) | 349.65(560.65) | 1480.40(2647.72) |
| 23 | Apparel, Finished Products from Fabrics and Similar Materials | 2.32(0.23) | 0.17(0.19) | 781.62(1828.02) | 2763.59(7662.50) |
| 24 | Lumber and Wood Products, except Furniture | 0.76(0.34) | 0.25(0.21) | 496.43(673.35) | 2626.05(4780.50) |
| 25 | Furniture and Fixtures | 1.32(1.19) | 0.17(0.20) | 575.07(1175.80) | 1536.50(2214.16) |
| 26 | Paper and Allied Products | 0.50(0.07) | 0.33(0.23) | 1092.86(1575.46) | 4966.15(7267.33) |
| 27 | Printing, Publishing and Allied Industries | 1.63(0.18) | 0.33(0.40) | 544.50(875.03) | 2960.16(5780.48) |
| 28 | Chemicals and Allied Products | 1.24(0.10) | 0.26(0.24) | 2053.58(4018.28) | 12538.81(26818.77) |
| 29 | Petroleum Refining and Related Industries | 1.55(0.30) | 0.19(0.12) | 19068.44(26602.55) | 84759.41(115105.50) |
| 30 | Rubber and Miscellaneous Plastic Products | 0.49(0.12) | 0.28(0.25) | 784.26(1489.55) | 2815.91(4724.05) |
| 31 | Leather and Leather Products | 0.89(0.09) | 0.08(0.12) | 353.40(337.82) | 1039.81(1116.23) |
| 32 | Stone, Clay, Glass, and Concrete Products | 2.91(0.13) | 0.26(0.21) | 995.78(2249.02) | 6370.44(13130.19) |
| 33 | Primary Metal Industries | 1.67(0.61) | 0.21(0.19) | 1571.01(3575.07) | 7583.07(17748.98) |
| 34 | Fabricated Metal Products, except Machinery and Transportation Equipment | 0.72(0.06) | 0.22(0.19) | 459.61(694.24) | 1852.01(2778.91) |
| 35 | Industrial and Commercial Machinery and Computer Equipment | 0.69(0.17) | 0.16(0.18) | 1327.90(3511.14) | 6751.49(16976.42) |
| 36 | Electronic and other Electrical Equipment and Components, except Computer Equipment | 0.82(0.23) | 0.15(0.19) | 1131.26(3759.96) | 6013.72(19822.97) |
| 37 | Transportation Equipment | 0.76(0.25) | 0.21(0.18) | 4622.80(10877.46) | 23465.51(64271.46) |
| 38 | Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, Optical Goods; Watches and Clocks | 0.49(0.11) | 0.15(0.17) | 737.96(1449.66) | 4537.84(9313.57) |
| 39 | Miscellaneous Manufacturing Industries | 2.01(0.30) | 0.18(0.21) | 389.07(740.96) | 2037.32(4412.19) |
| | Total / Average | 1.05(0.59) | 0.21(0.21) | 2017.01(6880.19) | 10143.97(33972.74) |

**Table 3.** Correlation table of final sample composition.

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | DSO | | | | | | | |
| 2 | DIO | 0.1635* | | | | | | |
| 3 | DPO | 0.2882* | 0.2493* | | | | | |
| 4 | CCC | 0.4021* | 0.8694* | -0.0930* | | | | |
| 5 | Capacity Slack | 0.0721* | 0.0205* | 0.0866* | 0.0059 | | | |
| 6 | Market Instability | -0.1696* | -0.0355* | -0.0431* | -0.0858* | 0.1165* | | |
| 7 | Leverage | -0.0841* | -0.0954* | 0.0007 | -0.1272* | 0.1094* | 0.0415* | |
| 8 | ln(Total Assets) | 0.0540* | -0.0499* | 0.2192* | -0.1297* | 0.1347* | 0.0062 | 0.2377* |

* $p < 0.05$

**Table 4.** CSCO in a firm Mixed Model Analysis

| | Model 1<br>***H1***<br><br>CCC | Model 2<br>***H1a***<br><br>DSO | Model 3<br>***H1b***<br><br>DIO | Model 4<br>***H1c***<br><br>DPO | Model 5<br>***H2***<br><br>CS |
|---|---|---|---|---|---|
| CSCO Presence | ***-12.20**** | ***-3.356**** | ***-9.843**** | -0.852 | ***-36.19**** |
| | (2.502) | (0.994) | (2.330) | (1.120) | (3.316) |
| Market Instability | -3.414 | -0.378 | -7.711 | -4.658*** | 2.165 |
| | (3.051) | (1.314) | (4.912) | (1.395) | (5.901) |
| ln(Assets) | -4.278*** | 1.497*** | -1.376*** | 4.410*** | 5.539*** |
| | (0.202) | (0.0802) | (0.188) | (0.0904) | (0.267) |
| Leverage | -24.69*** | -10.50*** | -20.93*** | -6.685*** | 12.28*** |
| | (1.725) | (0.685) | (1.605) | (0.772) | (2.284) |
| Recession | 1.781* | 2.072*** | -1.116 | -0.825* | 3.551** |
| | (1.031) | (0.411) | (0.975) | (0.462) | (1.385) |
| Intercept | 139.1*** | 47.07*** | 117.1*** | 26.70*** | 63.53*** |
| | (7.315) | (2.690) | (7.122) | (2.902) | (13.87) |
| Observations | 39,428 | 39,428 | 39,428 | 39,428 | 39,428 |
| Firms | 1,431 | 1,431 | 1,431 | 1,431 | 1,431 |
| Wald $chi^2$ | | | | | |
| Likelihood-ratio test of Rho=0 | 888.2*** | 516.0*** | 308.4*** | 2,439.6*** | 600.2*** |

Standard errors in parentheses
***Hypothesized results bolded and italicized***
* $p<0.1$, ** $p<0.05$, *** $p<0.01$

**Table 5.** Market Instability Interaction Effects Mixed Model Analysis

| | Model 6<br>***H3a***<br>DIO | Model 7<br>***H3b***<br>CS |
|---|---|---|
| CSCO Presence | ***-19.19**** | ***-41.46**** |
| | (5.382) | (7.659) |
| Market Instability | -7.963* | 2.031 |
| | (4.837) | (5.910) |
| CSCO Presence x Market Instability | 6.153* | 3.469 |
| | (3.193) | (4.544) |
| ln(Assets) | -1.373*** | 5.540*** |
| | (0.188) | (0.267) |
| Leverage | -20.91*** | 12.30*** |
| | (1.605) | (2.285) |
| Recession | -1.152 | 3.529** |
| | (0.975) | (1.385) |
| Intercept | 117.4*** | 63.69*** |
| | (7.081) | (13.86) |
| Observations | 39,428 | 39,428 |
| Firms | 1,431 | 1,431 |
| Wald $chi^2$ | 312.1*** | 600.8*** |
| Likelihood-ratio test of Rho=0 | 4,744.1*** | 5,543.9*** |

Standard errors in parentheses
***Hypothesized results bolded and italicized***
* p<0.1, ** p<0.05, *** p<0.01

**Table 6.** Summary of empirical test results

<table>
<tr><td colspan="3">Hypotheses Test Results</td></tr>
<tr><td rowspan="2">1</td><td colspan="2">(a) CCC</td></tr>
<tr><td colspan="2">Supported Overall<br>(H1a: DSO and H1b: DIO [Inventory slack] Supported,<br>H1c and H1c [alternate]: DPO Not Supported)</td></tr>
<tr><td rowspan="2">2</td><td colspan="2">(b) Capacity slack</td></tr>
<tr><td colspan="2">Supported</td></tr>
<tr><td rowspan="2">3</td><td>(a) DIO (Inventory slack) x Market Instability</td><td>(b) Capacity slack x Market Instability</td></tr>
<tr><td>Supported</td><td>Not Supported</td></tr>
</table>

**Table 7.** Temporal analysis of CSCOs and Supply Chain Performance

| | Model 8 CCC | Model 9 DSO | Model 10 DIO | Model 11 DPO | Model 12 CS | Model 13 CCC | Model 14 DIO | Model 15 DPO | Model 16 CS |
|---|---|---|---|---|---|---|---|---|---|
| CSCO Tenure | -0.705*** | -0.0491 | -0.436*** | 0.230*** | -1.513*** | -0.909*** | -0.992*** | -0.274* | -3.919*** |
| | (0.145) | (0.0574) | (0.135) | (0.0647) | (0.192) | (0.351) | (0.327) | (0.157) | (0.465) |
| $(\text{CSCO Tenure})^2$ | | | | | | 0.00693 | 0.0189* | 0.0171*** | 0.0816*** |
| | | | | | | (0.0109) | (0.0101) | (0.00486) | (0.0144) |
| Market Instability | -3.396 | -0.311 | -7.651 | -4.487*** | 2.856 | -3.418 | -7.710 | -4.537*** | 2.444 |
| | (3.068) | (1.360) | (4.908) | (1.329) | (6.460) | (3.063) | (4.900) | (1.331) | (6.270) |
| ln(Assets) | -4.295*** | 1.481*** | -1.400*** | 4.387*** | 5.446*** | -4.290*** | -1.388*** | 4.399*** | 5.500*** |
| | (0.202) | (0.0801) | (0.188) | (0.0903) | (0.267) | (0.202) | (0.188) | (0.0903) | (0.267) |
| Leverage | -24.75*** | -10.61*** | -21.06*** | -6.858*** | 11.75*** | -24.72*** | -20.98*** | -6.789*** | 12.08*** |
| | (1.724) | (0.685) | (1.605) | (0.772) | (2.285) | (1.725) | (1.605) | (0.772) | (2.285) |
| Recession | 1.816* | 2.115*** | -1.054 | -0.734 | 3.766*** | 1.804* | -1.087 | -0.764* | 3.633*** |
| | (1.031) | (0.411) | (0.975) | (0.461) | (1.388) | (1.031) | (0.975) | (0.461) | (1.387) |
| Intercept | 139.1*** | 47.06*** | 117.1*** | 26.57*** | 62.91*** | 139.2*** | 117.1*** | 26.59*** | 63.29*** |
| | (7.325) | (2.745) | (7.128) | (2.819) | (13.86) | (7.322) | (7.124) | (2.831) | (13.84) |
| Observations | 39,428 | 39,428 | 39,428 | 39,428 | 39,428 | 39,428 | 39,428 | 39,428 | 39,428 |
| Firms | 1,431 | 1,431 | 1,431 | 1,431 | 1,431 | 1,431 | 1,431 | 1,431 | 1,431 |
| Wald $\text{chi}^2$ | 888.2*** | 505.1*** | 301.0*** | 2,454.0*** | 542.8*** | 888.6*** | 304.5*** | 2,467.1*** | 575.4*** |
| Likelihood-ratio test of Rho=0 | 4,495.5*** | 2,804.0*** | 4,763.0*** | 2,083.9*** | 5,586.9*** | 4,494.8*** | 4,762.3*** | 2,082.4*** | 5,586.9*** |

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

**Figure 1.** Conceptual Model and Hypotheses

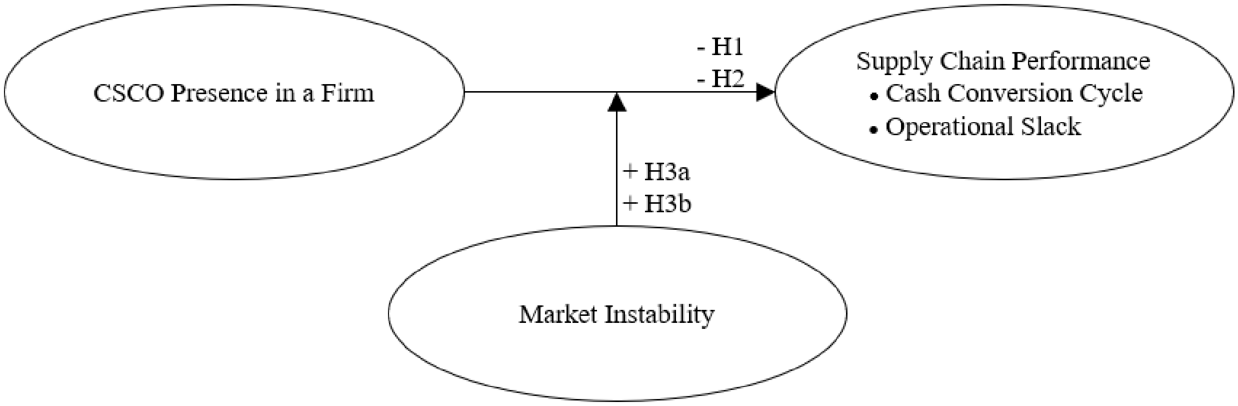


**Figure 2.** Cumulative Chief Supply Chain Officer (CSCO) Positions by Quarter (2008 to 2017)

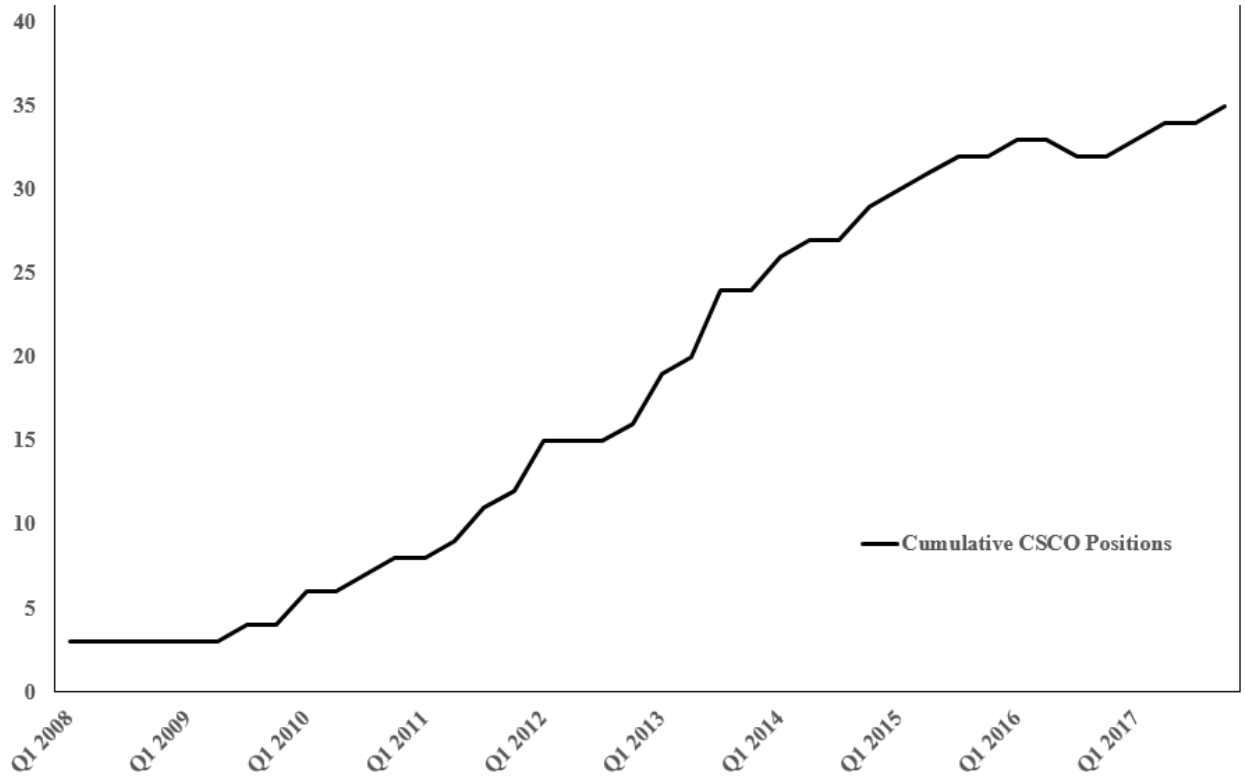


**Figure 3.** Relative change in DIO and DPO as CSCO Tenure increases

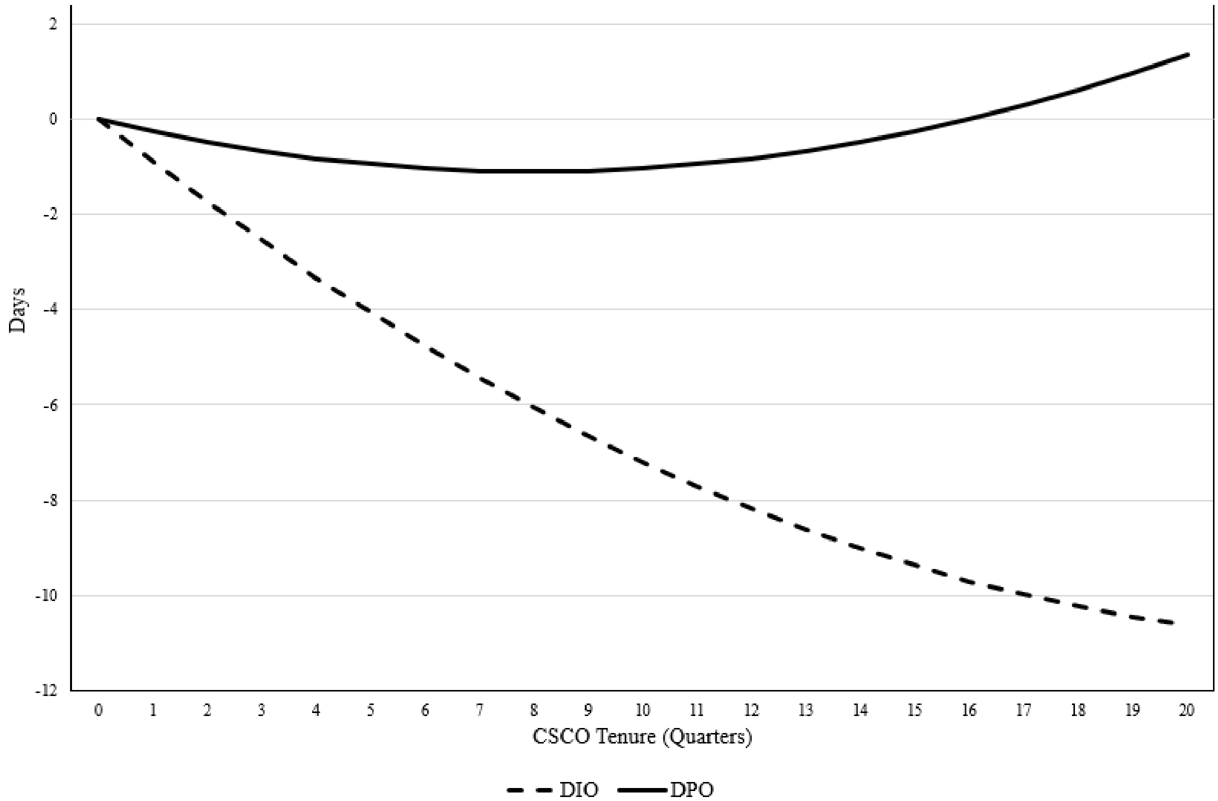
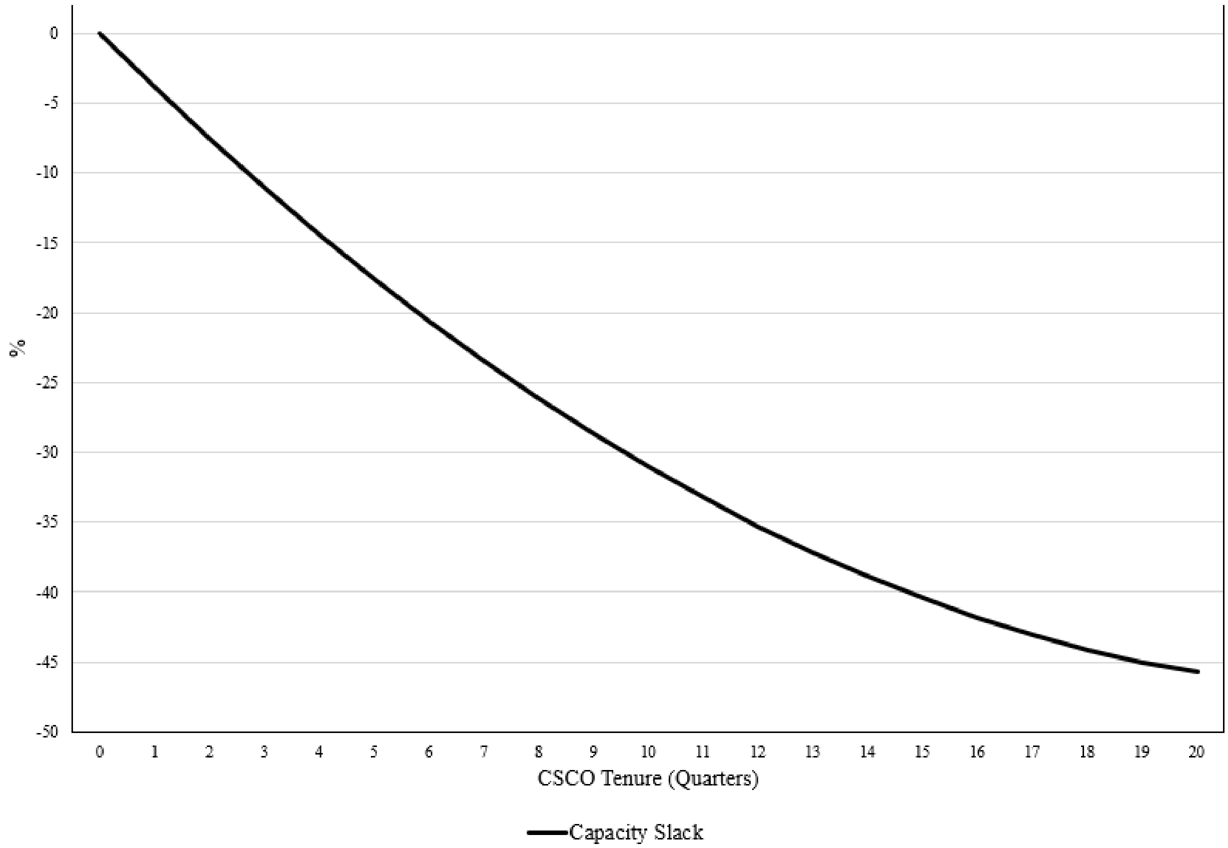


**Figure 4.** Relative change in Capacity Slack as CSCO Tenure increases



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