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# The cash-holding link within the supply chain\*

Tri Tri Nguyen, Manh Cuong Nguyen, Hung Quang Bui, and Tuyet Nhung Vu

## Abstract

Using a customer-supplier matched sample of US-listed firms from 1980 to 2016, we study the corporate cash-holding relationship between suppliers and their major customers. The key findings suggest that the cash-holding levels of suppliers are positively affected by those of their major customers, consistent with the liquidity argument. The effects are more pronounced when the major customers are in more favourable financial conditions and when they are considered more important to their suppliers. Our results are robust to various endogeneity problems and additional tests. Taken together, these results bring forth an important corporate cash-holding link within the supply chain.

**Keywords** Cash Holdings · Customer-supplier Relationships · Supply Chain

**JEL Classification** G30 · G31 · G32 · L14

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## 1 Introduction

This study examines whether and how major customer firms' cash holdings affect their supplier firms' cash-holding policies.<sup>2</sup> Suppliers have probably made significant relationship-specific investments in their relationships with their major customers, and supply a large proportion of their outputs to them, leading to a significant dependence on these business partners (Titman 1984; Titman and Wessels 1988). As a result, it is likely that suppliers' corporate financial policies, in general, and their cash-holding policies, in particular, will be influenced by those of their major customers. This has been referred to as the contagion of financial conditions and decision making within the supply chain. Indeed, studies within the customer-supplier relationships research strand have been providing growing evidence on the link between suppliers' financial conditions and decision making, and those of their major customers. For example, previous studies show that major customers' financial conditions affect their suppliers' capital structures and credit spreads (Gençay et al. 2015; Demirci 2016; Oliveira et al. 2017), and stock returns (Cohen and Frazzini 2008; Hertz et al. 2008; Cheng and Eshleman 2014; Madsen 2017). In addition, there is evidence of the transfer of financial distress from major customers to their suppliers (Huang and Ren 2017; Lian 2017). However, the issue of how major customers' cash holdings affect their suppliers' cash-holding policies has not been examined. In this paper, we seek to address this literature gap by shedding light on the cash-holding link within the supply chain. Examining such a link enriches our understanding of the contagion of financial conditions and decision making within the supply chain and the determinants of corporate cash holdings.

The literature offers two contrasting predictions to explain the relationship between suppliers' cash holdings and those of their major customers. The first view (hereafter the liquidity argument) holds that major customers' cash holdings should have a positive impact on those of their suppliers. This view is based on the notion that, since suppliers provide a large proportion

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<sup>2</sup> In this study, we define major customers (excluding government ones) as their suppliers' largest customers.

of their outputs to their major customers, the latter being in a healthy financial condition, including having strong cash reserves, may lead to the former experiencing favourable financial outcomes and vice versa. In particular, major customers with a strong liquidity position may be able to pay their suppliers quickly, while those with a cash shortage may have difficulty doing so. As major customers account for a significant proportion of their suppliers' total sales, it is likely that these business partners' ability to pay will have a significant impact on their suppliers' ability to accumulate cash. This is why suppliers, in practice, tend to have more incentives to do business with customers that are in a healthy financial condition, possibly to secure their own healthy financial condition (Kling et al. 2014). Previous studies have also documented that suppliers obtain more favourable terms on their loan contracts when their major customers are more profitable (Kim et al. 2015), and when lenders provide loans to both parties of the supply chain so that they can use the information about the major customer's financial condition to assess their supplier's creditworthiness (Gong and Luo 2018). Such evidence sheds further light on why suppliers prefer to do business with financially healthy customers. In short, it is likely that, when major customers have higher levels of cash holdings and hence are better able to make payments, their suppliers will be in a better position to accumulate cash and vice versa.

On the contrary, the second view (hereafter the precautionary argument) relates to the precautionary motive argument in the cash holdings literature and suggests that the cash-holding link between suppliers and their major customers should be a negative one. This is because, according to Itzkowitz (2013), being in highly bilateral relationships with just a few major customers creates a strong need for suppliers to hold precautionary cash as a preventive measure, since the loss of any of these important business partners could result in a severe, adverse cash flow shock and possibly financial distress. This precautionary motive of suppliers becomes stronger when their major customers have cash shortages since these firms in this situation may have less ability to pay and fulfil their purchase commitments to their suppliers. Further precautionary motives to hold more cash, for suppliers with major customers that are in financial trouble, are created by concerns over the contagion of risk within the supply chain. For example, Huang and Ren (2017) and Lian (2017) find that major customers' financial distress and credit rating downgrades may negatively affect their suppliers' financial condition and make it more difficult for them to access external finance. As a result, it is likely that there is a negative link

between suppliers' cash holdings and those of their major customers. That is, a supplier may hold more precautionary cash when they see that their major customer has a low level of cash holdings, but their precautionary motive for holding cash may become weaker when their major customer has a strong liquidity position.

Since the literature provides contrasting predictions about the impact of cash holdings of major customers on the cash holdings of their suppliers, it is ultimately an empirical question as to which view is more relevant. Using a customer-supplier matched sample of US-listed firms from 1980 to 2016, we find a positive, economically significant link between major customers' and their suppliers' cash holdings. This link is statistically significant at the 1% level and remains robust across different measures of cash holdings. In terms of economic significance, the results show that an increase of 1% in major customers' cash holdings leads to a rise from 0.197% to 0.247% in those of their suppliers. This evidence lends empirical support to the liquidity argument that major customers' cash holdings have a positive impact on those of their suppliers. Since these business partners account for a significant proportion of their suppliers' total sales, their level of cash holdings and hence ability to pay as well as fulfil their purchase commitments have a pronounced impact on their suppliers' ability to accumulate cash and therefore their levels of cash holdings.

Our findings suggest two possible channels to explain the impact of major customers' cash holdings on those of their suppliers. The first channel is the contagion of financial conditions within the supply chain. In particular, when major customers are in a favourable financial condition and have a strong liquidity position, it is likely that they will be better able to pay and fulfil their purchase commitments to their suppliers. As a result, given the suppliers' significant reliance on them, the suppliers may be better able to accumulate and retain cash. Following the prior literature, we measure major customers' financial condition using their liquidity position (e.g., deviation from target levels of cash holdings), dividend policies and growth opportunities (Bates et al. 2009). Firms are considered to be in a favourable financial condition when they (1) have excess cash, (2) pay dividends and (3) have more growth opportunities.<sup>3</sup> For example, as

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<sup>3</sup> In the finance literature, growth opportunities have usually been used as a measure of financial constraint (Opler et al. 1999; Bates et al. 2009). However, in this study, major customers with more growth

suggested by Bates et al. (2009), when major customers have excess cash, that is, their cash-holding levels are above their target levels, they may be better able to pay their suppliers. Paying their suppliers more quickly may allow them to maintain favourable relationships with them or obtain early-payment discounts. In line with our prediction, we find consistent evidence that the impact of major customers' cash holdings on those of their suppliers becomes more pronounced when these customers have excess cash, when they pay dividends, and when they have more growth opportunities. This evidence confirms the contagion of financial condition within the supply chain.

The second possible channel for explaining the impact of major customers' cash holdings on those of their suppliers is the former's importance to the latter. We argue that, in practice, major customers tend to be considered more important business partners by their suppliers when the latter depend more heavily on the former for sales and cash, and this hence leads to a more pronounced cash-holding link between the two parties of the supply chain. Following the prior literature, we measure major customers' importance to their suppliers using (1) the suppliers' sales to their major customers as a percentage of their total sales, (2) the suppliers' levels of customer concentration, and (3) the similarity of the nature of the two parties' businesses (Hoberg and Phillips 2010). Major customers are considered more important to their suppliers when the suppliers' sales to these business partners account for a larger proportion of the suppliers' total sales; the suppliers have higher levels of customer concentration and therefore depend more heavily on a small number of customers for sales and cash; and the two parties are from the same industry and it is therefore likely that they will be working with the same types of technologies, which could result in major customers having a greater demand for their suppliers' outputs. Consistent with our prediction, we find evidence that major customers' cash holdings have a more pronounced impact on those of their suppliers when the suppliers' sales to their major customers account for a greater proportion of their total sales; when the suppliers' levels of customer concentration are higher; and when the two parties are from the same industry.

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opportunities are not necessarily considered financially constrained given that the majority of customer firms in our sample are very large and well established.

There is a concern that our findings may be affected by several endogeneity problems, even though our baseline regressions use the major customers' lagged cash holdings and incorporate year and industry fixed effects. For example, it is possible that firms' cash holdings may be determined by industry practices, that is, an industry-specific demand that they hold more or less cash. We employ the instrumental approach to mitigate this endogeneity concern. Specifically, we use the two-year-lagged value of the industry-average cash holdings as an instrumental variable (e.g., Dhaliwal et al. 2016). The results remain consistent with our main findings.

The results also hold under several other endogeneity tests. First, we run firm fixed-effects and pair fixed-effects regressions to eliminate the influence of time-invariant supplier firm and customer-supplier relationship heterogeneity. Second, we employ the propensity score matching approach (e.g., Shipman et al. 2017) to deal with confounding factors. Third, we run regressions on a subsample which does not contain observations with cash-rich major customers, to deal with the sample selection problem wherein cash-rich suppliers may choose to do business with cash-rich major customers. Finally, we follow prior studies and perform falsification tests, using 2,000 simulation-based samples of fictitious customer-supplier relationships (Qiu et al. 2017; Cen et al. 2018; Chu et al. 2019), to see if the cash-holding link between suppliers and their major customers is genuine. All in all, although it is not possible to fully mitigate all endogeneity problems, the findings from these tests strongly support the notion of the liquidity argument that major customers' cash holdings positively affect those of their suppliers given the nature of their relationships.

This paper contributes to the literature in at least two ways. First, this work is related to the literature on the corporate cash holdings. Previous studies have identified the determinants of firms' cash holdings, i.e. firm fundamental characteristics (Opler et al. 1999; Bates et al. 2009), firm risks (Han and Qiu 2007; Riddick and Whited 2009; Acharya et al. 2013), agency issues (Dittmar et al. 2003; Hill et al. 2014), the burden of repatriation taxes (Foley et al. 2007), corporate governance (Dittmar and Mahrt-Smith 2007), and social responsibility (Cheung 2016). Opler et al. (1999) and Bates et al. (2009) find that firms' levels of cash holdings are jointly determined by several firm-level characteristics, including size, leverage, net working capital, market-to-book ratios, operating cash flows, capital expenditures, dividend payout, and research and development expenses. For example, according to these authors, firms with more volatile

operating cash flows tend to hold more cash so that they can better cope with adverse cash flow shocks. Similarly, Han and Qiu (2007) and Riddick and Whited (2009) find that firm risks are positively related to their levels of cash holdings. Dittmar et al. (2003) show that firms in countries with weak protection of shareholder rights and those with more agency problems need to hold more cash. Dittmar and Mahrt-Smith (2007) find that there is a negative link between the strength of corporate governance and cash holdings, i.e., that firms with poor corporate governance dissipate excess cash reserves more quickly on less profitable investments than those with good governance. According to Foley et al. (2007), firms facing higher repatriation taxes hold more cash to lower the burden of repatriation taxes. Acharya et al. (2013) find that firms use cash reserves as a hedge against future financing and predation risks. Most recently, Hill et al. (2014) show that firms with stronger political connections hold less cash to reduce the agency and opportunity costs of holding cash. Cheung (2016) finds that socially responsible firms hold more cash than socially irresponsible ones as their main objective is to maximize stakeholders' wealth rather than shareholders' wealth. Our paper, however, focuses more on the cash holding effects through supply chain. The paper contributes to this literature by documenting the effect of major customers' cash holdings on their suppliers' cash holdings.

Second, prior supply chain literature tends to focus on the close link between suppliers' financial condition and supplier's financial leverage (Gençay et al. 2015; Demirci 2016; Oliveira et al. 2017; Liu et al. 2018), stock returns (Cohen and Frazzini 2008; Hertz et al. 2008; Cheng and Eshleman 2014; Madsen 2017), and bankruptcy risk and the probability of financial distress (Huang and Ren 2017; Lian 2017). Gençay et al. (2015) show that major customers' leverage and option-implied volatility have a positive impact on their suppliers' credit spreads. According to Demirci (2016), there is a significant fall in suppliers' leverage and net debt issuance activities following an increase in their major customers' risk, and changes in major customers' credit ratings tend to lead to similar changes in their suppliers' credit ratings. Oliveira et al. (2017) find that major customers' financial distress results in a rise in their suppliers' financial leverage prior to the former's filing dates, since these suppliers may have incentives to increase their leverage to fortify their bargaining power when their major customers are in financial distress. Liu et al. (2018) find that having risky major customers reduces suppliers' access to external financing. According to Cohen and Frazzini (2008), shocks to major customers' stock prices translate into



shocks to their suppliers' stock prices. This is largely consistent with the finding of Hertz et al. (2008) that major customers' distress related to bankruptcy filings is related to negative and significant stock price effects for their suppliers. Cheng and Eshleman (2014) find that the stock prices of suppliers overreact to customer earnings announcements. Similarly, Madsen (2017) finds that major customers' stock returns predict their suppliers' stock returns shortly before the suppliers' earnings announcements. Huang and Ren (2017) find that suppliers' bankruptcy risk is significantly associated with that of their major customers, which results in a positive link between the two parties' credit ratings. Consistent with this, Lian (2017) shows that suppliers' financial distress is positively linked to their major customers' distress risk, and the link becomes more pronounced when their relationships are stronger. However, there has been no empirical evidence on the cash-holding link between the two parties. Our study helps fill this gap in the literature by showing that the contagion of financial conditions and decision making within the supply chain, apart from the influence of major customers' financial condition on their suppliers' financial leverage, stock return, and bankruptcy risk, are also embodied in the cash-holding link between the two parties.

The rest of the paper proceeds as follows. We review the literature and develop the hypotheses in Section 2. We explain sample construction, data sources, and model specification in Section 3. We then present the main results and robustness checks in Section 4, and possible channels in Section 5. Finally, we provide some concluding remarks in Section 6.

## **2 Literature review and hypothesis development**

### **2.1 The major theories of cash holdings**

The theoretical frameworks for corporate cash holdings are largely similar to those for corporate leverage. In particular, according to the trade-off view (Opler et al. 1999; Dittmar et al. 2003; Ozkan and Ozkan 2004; Bates et al. 2009; Venkiteshwaran 2011; Lin and Chiu 2017; Nguyen 2019; Amin and Williamson 2020), firms have target levels of cash holdings which help to balance between the marginal benefits of cash and its marginal costs. The major benefits of cash are implied by the transaction cost motive, the precautionary motive, the tax motive, and the

speculative motive arguments. In particular, the transaction cost motive argument holds that, by holding sufficient levels of cash, firms can save on the transaction costs associated with converting cash substitutes into cash (Baumol 1952; Miller and Orr 1966). Meanwhile, according to the precautionary motive argument, firms hold cash to better cope with adverse cash flow shocks when access to capital markets is costly (Opler et al. 1999; Adams et al. 2009; Amess et al. 2015; Gao 2015; Chen et al. 2016) or when there is a high cash flow risk (Han and Qiu 2007). From the viewpoint of the tax motive argument, firms hold more cash to avoid additional tax liabilities in the presence of tax uncertainty (Hanlon et al. 2017) or to reduce tax consequences associated with the repatriation of foreign earnings (Foley et al. 2007). Finally, the speculative motive argument suggests that firms hold cash to grasp future positive NPV (net present value) investment opportunities more effectively (Kim et al. 1998).

Meanwhile, the major costs of cash take the forms of the opportunity costs of holding a low-return asset and the rise in agency costs of managerial discretion. The opportunity costs of holding a low-return asset have usually been called the cost-of-carry, which refers to the difference between the return on cash and the interest firms would have to pay to finance an additional dollar of cash (Dittmar et al. 2003). With regard to agency costs of managerial discretion, the free cash flow hypothesis, alternatively known as the agency motive argument, postulates that entrenched managers would rather retain cash than pay more dividends to their shareholders, even when their firms have negative *NPV* investment opportunities (e.g., Lang and Litztenberger 1989; Lang et al. 1991). The trade-off view also suggests that, since deviations from target levels of cash holdings are costly, firms actively adjust toward these levels over time, although the presence of adjustment costs will prevent them from doing so in a continuous manner. Studies in support of the trade-off view have hence identified several determinants of firms' cash holdings, the most important ones being size, leverage, net working capital, market-to-book ratio, operating cash flow, capital expenditure, dividend payout, research and development expenses, credit rating and age.

Different from the trade-off view, the pecking order view of corporate cash holdings holds that firms should finance their investment opportunities first with internal financing (e.g., retained earnings), and then external financing (e.g., debt first and then equity), to minimize asymmetric information costs and other financing costs (Myers 1984; Myers and Majluf 1984). The

implication here is that firms do not have an optimal level of cash holdings, and cash by nature is just a buffer between their internal financing and investment needs. In other words, firms' cash holdings can, to a large extent, be considered the net result of their financing and investment decisions.

## **2.2 The link between suppliers' and their major customers' cash holdings**

The theoretical literature offers two contrasting predictions to explain the link between suppliers' and their major customers' cash holdings. The first view holds that there is a positive relation between major customers' cash holdings and those of their suppliers. This argument is in line with the liquidity argument and recent studies which show a positive link between customers being in a healthy financial condition and their suppliers experiencing favourable financial outcomes. For example, Kim et al. (2015) find that suppliers receive favourable terms on loan contracts from banks when their customers are more profitable. Similarly, Gong and Luo (2018) show that supply-chain lenders that provide loans to both suppliers and their customers tend to offer favourable lending contract terms (e.g., fewer accounting-based covenants or longer debt maturity) to suppliers. This is because these lenders can use the customers' financial information to assess their suppliers' creditworthiness and thereby make better decisions on how much monitoring is necessary when lending to the suppliers.

In their bilateral relationships with their major customers, suppliers' ability to accumulate cash may depend significantly on their major customers' liquidity positions, given their heavy reliance on these business partners for sales and hence cash. The existing literature shows that suppliers are more likely to provide trade credit to customers with high levels of cash holdings (Kling et al. 2014). This suggests that customers in a favourable financial condition may find it easier to purchase products and services from their suppliers, as they will be better able to pay and maintain long-term relationships with their suppliers by fulfilling their purchase commitments to them. In brief, suppliers supply a large proportion of their outputs to their major customers, and are therefore more likely to secure healthy cash inflows from major customers that have strong cash reserves. In other words, cash-rich customers are better able to pay and fulfil their long-term purchase commitments, which results in their suppliers being better able to

accumulate and retain cash. In addition, empirical studies confirm the positive link between cash flows from operating activities and cash holdings (Ferreira and Vilela 2004; Ozkan and Ozkan 2004). As a result, it is plausible that the increase in suppliers' cash flows is driven by that in their major customers' cash holdings, leading to a rise in the suppliers' cash holdings. We, therefore, develop the following hypothesis:

*Hypothesis 1a: Suppliers' cash holdings are positively affected by those of their major customers.*

Other streams of research derive the opposite prediction which relies on the precautionary motive argument, suggesting that suppliers' cash holdings are inversely determined by those of their major customers. The suppliers' precautionary motive for holding cash is mainly driven by their heavy reliance on their major customers for sales and cash, given that they supply a large proportion of their outputs to these business partners and may have made significant relationship-specific investments in their relationships with them. The unique nature of the relationships between suppliers and their major customers makes suppliers' precautionary motive for holding cash particularly pronounced. As suggested by Titman (1984) and Titman and Wessels (1988), the establishment of major customer-supplier relationships requires long-term purchase commitments, as well as relationship-specific investments that represent a significant cost for suppliers. Such investments can lead to significant switching costs, and can only be recovered if these firms manage to maintain their relationships with their major customers. The loss of major customers would be detrimental to the suppliers as it might result in severe adverse cash flow shocks due to losing the significant amounts of cash generated from sales to these customers. In addition, it may be both difficult and time consuming to find alternative customers, given the unique nature of the relationship-specific investments they will have made in the original relationship. In light of the increasingly intense competition in the marketplace, and hence the low switching costs for customers, hardly any suppliers can guarantee being able to retain their major customers forever. It is therefore essential for suppliers to hold additional cash so as to be in a good position to cope with any adverse cash flow shocks caused by the loss of a major customer. Indeed, Itzkowitz (2013) finds that firms in highly bilateral relationships with their major customers hold more precautionary cash, since the loss of these business partners could lead to severe adverse cash flow shocks and possibly financial distress.

Also, there is growing evidence of the spread of risk along the supply chain, which gives suppliers a further precautionary motive for holding cash. For example, Lian (2017) finds that a major customer's financial distress leads to financial distress for their suppliers, and this effect lasts for about two years after the former's time of financial distress, due to a reduction in the customer's demand for their suppliers' products and services. In addition, Huang and Ren (2017) show that suppliers' credit ratings decrease following a downward movement in the rating of a major customer. Since financial distress or a lower credit rating may hinder suppliers' access to external finance, they should retain high levels of cash holdings as a precaution.

In brief, being in highly bilateral relationships with their major customers gives suppliers a precautionary motive to hold more cash. That motive becomes more pronounced when the major customers do not have strong liquidity positions, for two reasons. First, these customers may have less ability to pay and fulfil their purchase commitments, which may lead to suppliers having concerns about losing them and hence experiencing adverse cash flow shocks and possibly financial distress. Second, the evidence on the spread of risk along the supply chain may lead suppliers to worry about ending up in the same situation as their financially troubled customers. However, when major customers have strong cash reserves, their suppliers' precautionary motive for holding cash may become weaker. We hence conjecture that there is a negative link between suppliers' and their major customers' cash holdings, and develop the following competing hypothesis:

*Hypothesis 1b: Suppliers' cash holdings are negatively influenced by those of their major customers.*

### **3 Sample construction, data sources and model specification**

#### **3.1 Sample construction and data sources**

We obtain the data for this study from different sources, including the CRSP/*Compustat* database and the *Compustat* Segment Customer file. We first extract the fundamental data for US listed firms from the CRSP/*Compustat* database, excluding financial firms (i.e., firms with Standard

**Table 1** Sample collection procedure

Description	Observations
Matched firm-year observations between suppliers and their largest customers (with valid GVKEY), excluding financial and utility suppliers and customers	27,720
<i>Less:</i> Observations where the customer is not the largest	(7,834)
<i>Less:</i> Observations with missing data for either suppliers' or customers' variables	(8,481)
Remaining firm-year observations (pairs) of suppliers and their largest customer	<u>11,405</u>
<i>Less:</i> Observations where customer-supplier pair has existed for less than five years	(3,726)
Final sample (firm-year observations) of supplier-customer pairs from 1980 to 2016 with sufficient data for main analyses	<u><b>7,679</b></u>

This table describes our sample collection procedure.

Industry Classification (SIC) codes from 6000 to 6999) and utility firms (i.e., firms with SIC codes from 4900 to 4999), as these organizations tend to be subject to heavy regulation and hence might exhibit atypical cash-holding behaviours. Following the existing literature, we also delete firms with negative assets or negative stock prices. This procedure produces 132,107 firm-year observations (of both suppliers which report their major customers and suppliers which do not) for the period from 1980 to 2016 with sufficient data to calculate the different measures of cash holdings and the control variables. This sample is used to estimate firms' target levels of cash holdings. All the variables of interest are winsorized at the 1<sup>st</sup> and 99<sup>th</sup> percentiles to avoid any influence from outliers.

We then follow previous studies (e.g., Fee and Thomas 2004; Lian 2017; Chu et al. 2019; Nguyen et al. 2020) and use the *Compustat* Segment Customer file to match suppliers with their major customers. This dataset contains information on suppliers' sales to those major customers which account for at least 10% of their total annual sales, in accordance with Statement of Financial Accounting Standards (SFAS) No. 14, and those to other customers which do not meet this sales contribution threshold but are still considered important business partners, in accordance with SFAS No. 131. The matching procedure is as follows. We start with all US public firms in the CRSP/*Compustat* database for the period from 1980 to 2016. We then remove firms with missing total assets. At the same time, we obtain data on sales to major customers from the *Compustat* Segment Customer file and delete observations with missing sales, missing

customer names, nonsensical customer names (e.g., “NOT REPORTED”), and general customers (e.g., “JAPAN MARKET”). This is because there is not enough information to identify these customers or evaluate how important they are to their suppliers.

After that, we adopt a string-matching method similar to that used in previous studies (Fee and Thomas 2004; Lian 2017; Chu et al. 2019) to match suppliers to their customers. To be specific, we use a text-matching method, which finds and matches similar sequences of letters, to create a list of customers’ names from the *Compustat* Segment Customer file and potential matched firm names in the *CRSP/Compustat* database. We then classify all matches into two categories: (a) exact matches where we have an exact sequence of letters in the names of firms in both the *Compustat* Segment Customer file and the *CRSP/Compustat* database, and (b) close matches where there are small differences in the sequences of letters between a customer’s name in the *Compustat* Segment Customer file and a firm’s name in the *CRSP/Compustat* database. We then manually check the close matches in (b), using different sources of information, such as SEC filings, firms’ websites, and Bloomberg’s firm information, to make sure that we have the same firm in each close match. This approach can result in true matches even when the customers’ names in the *Compustat* Segment Customer file are written as abbreviations (Fee and Thomas, 2004). However, in some cases, customers’ names are written in a very abbreviated form. Following previous studies that use the same approach, we make our best guesses about what these very short abbreviations mean and search for firm names in the *CRSP/Compustat* database.

The above matching procedure results in 27,720 pairs of suppliers and their customers with a valid GVKEY during the sample period from 1980 to 2016. This sample is comparable to those of previous studies such as Lian (2017) and Chu et al. (2019). In the final steps, we match the fundamental data in the *CRSP/Compustat* database with supplier-customer data on firm features, using the suppliers’ or customers’ GVKEYs. We then remove observations where the customer is not their supplier’s largest customer, observations with missing data needed for the main regressions, and observations where the customer-supplier pair has been in a relationship for less

than five years.<sup>4</sup> Our final sample has 7,679 firm-year observations with sufficient data on both the suppliers and their major customers for the study's main regressions. The sample collection procedure is presented in Table 1.

### 3.2 Model specification

To test *Hypotheses 1a* and *1b*, we follow previous studies in cash holdings (e.g., Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016; Brick and Liao 2017; Nguyen 2019) and in supply chain finance (e.g., Lian 2017; Bauer et al. 2018; Chu et al. 2019) to adopt the following regression model:

$$S\_CASH_t = \beta_0 + \beta_1 C\_CASH_{t-1} + \beta_2 S\_Control_{t-1} + \beta_3 C\_Control_{t-1} + \varepsilon_t \quad (1)$$

where the dependent variable  $S\_CASH_t$  is the cash-holding level of a supplier in year  $t$ , while  $C\_CASH_{t-1}$  stands for the cash-holding level of their major customer in year  $t-1$ . In this study, a major customer is defined as their supplier's largest customer, as reported in the *Compustat* Segment Customer file.

We employ four different measures of cash holdings which have been popularly used in the current cash-holding literature to ensure that our main findings are not sensitive to the use of such measures. To be specific, the first measure is the ratio of cash to total assets (*CASH1*) (Opler et al. 1999; Bates et al. 2009; Itzkowitz 2013; Jiang and Lie 2016; Nguyen 2019). This is the most traditional measure of cash holdings. The second measure is the ratio of cash and cash equivalents to net assets, where net assets are equal to total assets minus cash and cash equivalents (*CASH2*) (Opler et al., 1999; Bates et al., 2009; Itzkowitz, 2013; Jiang and Lie, 2016). The major rationale for the use of net assets in the construction of *CASH2* is that firms' ability to generate future profits is assumed to be a function of their assets in place (Opler et al., 1999). The last two measures are the natural logarithm of one plus the ratio of cash and cash equivalents to total assets (*CASH3*) (Foley et al., 2007; Bates et al., 2009) and the natural

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<sup>4</sup> In one of our unreported analyses, we retain observations in which the customer-supplier relationship has existed for less than five years and find that this does not qualitatively change our OLS results on the positive link between suppliers' and their major customers' cash holdings.



logarithm of one plus the ratio of cash and cash equivalents to net assets (*CASH4*) (Opler et al., 1999; Foley et al., 2007; Bates et al., 2009; Hill et al., 2014). The use of the natural logarithm reduces the magnitude of the problem of extreme outliers for firms with most of their assets in cash (Foley et al., 2007; Bates et al., 2009).

Consistent with existing studies in corporate cash holdings (Opler et al. 1999; Dittmar et al. 2003; Ozkan and Ozkan 2004; Bates et al. 2009; Venkiteshwaran 2011; Itzkowitz 2013; Jiang and Lie 2016; Lin and Chiu 2017; Nguyen 2019; Amin and Williamson 2020), we control for a set of important supplier characteristics (*S\_Control*) which jointly determine these firms' levels of cash holdings. They include growth opportunities (*S\_GO*), firm size (*S\_FS*), book leverage (*S\_BL*), cash flows (*S\_CF*), cash flow volatility (*S\_CFV*), capital expenditures (*S\_CAPEX*), net working capital (*S\_NWC*), research and development expenses (*S\_R&D*), dividend payout (*S\_PAYOUT*), credit rating (*S\_RATED*), and Firm age (*S\_LNAGE*). In addition to the supplier controls, we follow studies in supply chain finance (e.g., Bauer et al. 2018; Chu et al. 2019) to control for their major customers' main characteristics (*C\_Control*). These customer controls are growth opportunities (*C\_GO*), firm size (*C\_FS*), book leverage (*C\_BL*), cash flows (*C\_CF*), cash flow volatility (*C\_CFV*), capital expenditure (*C\_CAPEX*), net working capital (*C\_NWC*), research and development expenditure (*C\_R&D*), dividend payout (*C\_PAYOUT*), credit rating (*C\_RATED*), and firm age (*C\_LNAGE*), all of which may influence suppliers' cash-holding decisions. We describe the variable measurement and definition for the variables used in our analysis in Appendix A and B. We also control for year fixed effects and industry fixed effects to capture the potential differences in cash holdings over years and across industries. As suggested by Petersen (2009), we cluster the standard errors at the firm level to control for serial correlation.

## **4 Main results**

### **4.1 Descriptive statistics**

Table 2 summarizes the key descriptive statistics of the variables considered in this paper. For the period from 1980 to 2016, our sample has 7,679 firm-year pairs of suppliers and their largest customers, each pair having existed for at least five years. The table reports the key

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characteristics of the sample suppliers (Panel A), the major customers (Panel B), and other firms which are not the sample supplier firms (Panel C). Overall, the magnitudes of the standard deviations indicate a reasonable level of variation in our sample and are largely comparable to those reported in previous studies (e.g., Lian 2017; Chu et al. 2019). The table shows that suppliers, on average, have higher levels of cash holdings than their major customers, as well as other firms in the economy. This evidence is consistent with the finding of Itzkowitz (2013) that being in a highly bilateral relationship with their major customer leads to a rise in a supplier's precautionary cash holdings.

Table 2 Descriptive statistics

Variables	Panel A - Supplier firms			Panel B - Major customer firms			Panel C - Other firms in the economy					
	N	MEAN	MEDIAN	STD	N	MEAN	MEDIAN	STD	N	MEAN	MEDIAN	STD
<i>CASH1<sub>t</sub></i>	7,679	0.190	0.103	0.212	7,679	0.103***	0.056***	0.114	124,428	0.155***	0.080***	0.189
<i>CASH2<sub>t</sub></i>	7,679	0.439	0.114	0.920	7,679	0.144***	0.060***	0.264	124,428	0.341***	0.087***	0.844
<i>CASH3<sub>t</sub></i>	7,679	0.160	0.098	0.163	7,679	0.093***	0.055***	0.094	124,428	0.133***	0.077***	0.146
<i>CASH4<sub>t</sub></i>	7,679	0.265	0.108	0.378	7,679	0.119***	0.058***	0.159	124,428	0.210***	0.083***	0.337
<i>BL<sub>t</sub></i>	7,679	0.240	0.202	0.242	7,679	0.222***	0.230***	0.128	124,428	0.284***	0.224***	0.319
<i>CAPEX<sub>t</sub></i>	7,679	0.050	0.033	0.056	7,679	0.062***	0.058***	0.043	124,428	0.062***	0.042***	0.065
<i>CF<sub>t</sub></i>	7,679	0.020	0.066	0.214	7,679	0.080***	0.082***	0.077	124,428	-0.042***	0.058***	0.397
<i>CFV<sub>t</sub></i>	7,679	0.084	0.043	0.167	7,679	0.024***	0.015***	0.038	124,428	0.140***	0.041	0.381
<i>FS<sub>t</sub></i>	7,679	5.846	5.744	2.102	7,679	9.903***	10.389***	1.356	124,428	5.334***	5.285***	2.410
<i>GO<sub>t</sub></i>	7,679	1.591	1.160	1.521	7,679	1.581	1.263***	1.223	124,428	1.725***	1.084***	2.098
<i>LNAGE<sub>t</sub></i>	7,679	2.738	2.773	0.642	7,679	3.191***	3.332***	0.507	124,428	2.450***	2.485***	0.685
<i>NWC<sub>t</sub></i>	7,679	0.102	0.099	0.223	7,679	0.018***	-0.014***	0.137	124,428	0.026***	0.069***	0.426
<i>PAYOUT<sub>t</sub></i>	7,679	0.323	0.000	0.468	7,679	0.806***	1.000***	0.395	124,428	0.352***	0.000***	0.478
<i>RATED<sub>t</sub></i>	7,679	0.283	0.000	0.450	7,679	0.881***	1.000***	0.324	124,428	0.211***	0.000***	0.408
<i>R&amp;D<sub>t</sub></i>	7,679	0.200	0.014	0.778	7,679	0.042***	0.001***	0.215	124,428	0.157***	0.000***	0.763

This table shows the key descriptive statistics of the main variables considered in the paper, including number of observations (N) mean (MEAN), median (MEDIAN) and standard deviation (STD), for the period from 1980 to 2016. Panels A-C report the characteristics of the sample supplier firms, major customer firms, and other firms in the economy, respectively. The table also reports mean and median differences in firm characteristics between suppliers and their major customers and between suppliers and other firms in the economy. \*\*\*, \*\*, and \* indicate that the mean/median differences are statistically significant at the 1%, 5%, and 10% levels of significance, respectively. All the variables are winsorized at 1% and 99%. The variables' definitions are provided in the Appendix B.

Also, there are some significant differences between the suppliers' firm features and those of their major customers. For example, we find that, compared to their major customers, suppliers have much lower cash flows, smaller firm sizes, younger firm ages, lower dividend payouts, and lower credit ratings, but much higher cash flow volatilities and more growth opportunities. These statistics are comparable to those reported in previous studies (e.g., Lian 2017; Chu et al. 2019) and imply that suppliers are overall much smaller and less well established.

In addition, we find some important differences between suppliers which depend significantly on their major customers, and other firms in the economy. Specifically, the aforementioned suppliers have lower levels of leverage, lower levels of cash flow volatility, and higher levels of net working capital. Such features are generally consistent with the precautionary motive argument. For example, according to Kale and Shahrur (2007) and Banerjee et al. (2008), suppliers with a significant reliance on their major customers try to lower their risk by maintaining a capital structure with lower leverage.

## 4.2 Multivariate analysis

Table 3 reports our baseline regression results. Using different measures of cash holdings, we find consistent evidence that major customers' cash holdings ( $C\_CASH_{t-1}$ ) have a positive impact on those of their suppliers ( $S\_CASH_t$ ). The magnitudes of that influence are found to be broadly similar across the four different measures of cash holdings. In particular, we find that a one-unit increase in  $C\_CASH_{t-1}$  results in an increase from 0.197 to 0.247 units in  $S\_CASH_t$ , which is highly significant in economic terms. The  $t$ -statistics for the estimation coefficients on  $C\_CASH_{t-1}$  are between 2.83 and 5.44, indicating that the estimations are statistically significant at the 1% level. This finding lends support to *Hypothesis 1a* and the liquidity argument, which holds that there is a positive cash-holding link between suppliers and their major customers as the former supply a large proportion of their outputs to the latter, and the latter's levels of cash holdings and hence their ability to pay can positively affect the former's ability to accumulate and retain cash.

**Table 3** Baseline regression results

	CASH1 (1)	CASH2 (2)	CASH3 (3)	CASH4 (4)
<i>C_CASH<sub>t-1</sub></i>	<b>0.197***</b> (5.09)	<b>0.247***</b> (2.83)	<b>0.197***</b> (5.44)	<b>0.212***</b> (4.07)
<i>S_GO<sub>t-1</sub></i>	0.024*** (6.84)	0.063*** (4.16)	0.019*** (7.25)	0.036*** (5.70)
<i>S_FS<sub>t-1</sub></i>	-0.000 (-0.15)	-0.021* (-1.89)	0.000 (0.09)	-0.005 (-0.93)
<i>S_BL<sub>t-1</sub></i>	-0.299*** (-13.33)	-0.957*** (-9.96)	-0.237*** (-13.61)	-0.480*** (-12.16)
<i>S_CF<sub>t-1</sub></i>	-0.059** (-2.28)	-0.438*** (-3.00)	-0.041** (-2.10)	-0.141*** (-2.78)
<i>S_CFV<sub>t-1</sub></i>	-0.040 (-1.44)	-0.284** (-2.10)	-0.027 (-1.28)	-0.096* (-1.88)
<i>S_CAPEX<sub>t-1</sub></i>	-0.505*** (-7.63)	-1.921*** (-6.38)	-0.383*** (-7.62)	-0.892*** (-7.31)
<i>S_NWC<sub>t-1</sub></i>	-0.212*** (-8.24)	-0.724*** (-6.35)	-0.163*** (-8.39)	-0.357*** (-7.57)
<i>S_RD<sub>t-1</sub></i>	0.061*** (9.53)	0.427*** (7.72)	0.042*** (9.24)	0.143*** (9.23)
<i>S_PAYOUT<sub>t-1</sub></i>	-0.031*** (-3.44)	-0.074** (-2.47)	-0.025*** (-3.47)	-0.046*** (-3.12)
<i>S_LNAGE<sub>t-1</sub></i>	-0.019*** (-3.36)	-0.077*** (-3.59)	-0.014*** (-3.15)	-0.035*** (-3.69)
<i>S_RATED<sub>t-1</sub></i>	-0.013 (-1.32)	-0.020 (-0.57)	-0.010 (-1.20)	-0.020 (-1.21)
<i>C_GO<sub>t-1</sub></i>	0.002 (0.54)	0.024* (1.94)	0.000 (0.22)	0.007 (1.35)
<i>C_FS<sub>t-1</sub></i>	0.009** (2.17)	0.017 (1.08)	0.007** (2.33)	0.012* (1.70)
<i>C_BL<sub>t-1</sub></i>	0.031 (1.09)	0.221* (1.72)	0.025 (1.14)	0.068 (1.36)
<i>C_CF<sub>t-1</sub></i>	0.009 (0.15)	0.025 (0.07)	0.008 (0.18)	0.007 (0.06)
<i>C_CFV<sub>t-1</sub></i>	-0.078 (-0.67)	-0.253 (-0.62)	-0.059 (-0.66)	-0.137 (-0.70)
<i>C_CAPEX<sub>t-1</sub></i>	-0.124 (-1.54)	-0.696** (-2.15)	-0.085 (-1.35)	-0.265* (-1.94)
<i>C_NWC<sub>t-1</sub></i>	0.064** (1.98)	0.011 (0.10)	0.053** (2.10)	0.070 (1.32)
<i>C_RD<sub>t-1</sub></i>	0.023 (1.11)	-0.071 (-0.44)	0.020 (1.30)	0.016 (0.34)
<i>C_PAYOUT<sub>t-1</sub></i>	-0.028** (-2.52)	-0.054 (-1.33)	-0.022*** (-2.65)	-0.039** (-2.08)
<i>C_LNAGE<sub>t-1</sub></i>	-0.004 (-0.51)	-0.020 (-0.65)	-0.003 (-0.47)	-0.008 (-0.59)
<i>C_RATED<sub>t-1</sub></i>	0.022 (1.47)	0.052 (0.81)	0.016 (1.40)	0.035 (1.31)
<i>Constant</i>	0.175*** (3.22)	0.809*** (4.28)	0.129*** (2.89)	0.337*** (3.95)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7,679	7,679	7,679	7,679
Adjusted <i>R</i> <sup>2</sup>	0.524	0.465	0.525	0.514

This table reports the results of the OLS regressions on the link between the suppliers' cash holdings in year  $t$  ( $S\_CASH_t$ ) and their major customers' cash holdings in year  $t-1$  ( $C\_CASH_{t-1}$ ), as specified by Model (1), for the sample period from 1980 to 2016, using four different measures of cash holdings. The variables' definitions are provided in the Appendix B. Figures in parentheses are  $t$ -statistics. \*\*\*, \*\*, and \* indicate that the coefficients are statistically significant at the 1%, 5%, and 10% levels, respectively.

We now turn to the control variables. The estimation coefficients on most of the supplier characteristic controls are statistically significant and have signs consistent with the existing evidence in the corporate cash-holding literature (Opler et al. 1999; Dittmar et al. 2003; Ozkan and Ozkan 2004; Bates et al. 2009; Venkiteshwaran 2011; Lin and Chiu 2017; Nguyen 2019; Amin and Williamson 2020). Indeed, we find that the suppliers' firm size, leverage, cash flows, capital expenditure, net working capital, dividend payout, firm age, and credit rating have a negative impact on their cash holdings, while growth opportunities and research and development expenditure have a positive influence on them. However, on average, these same characteristics of the suppliers' major customers do not have a significant impact on the suppliers' cash holdings.

In brief, we find new evidence in support of *Hypothesis 1a* and the liquidity argument that major customers' cash holdings have a positive impact on those of their suppliers. As suppliers supply a large proportion of their outputs to their major customers, they can better accumulate cash when these business partners have strong cash reserves, because cash-rich customers are more able to pay and fulfil their long-term purchase commitments to their suppliers.

### **4.3 Robustness checks**

In our first robustness check, we examine whether our findings are sensitive to alternative measures of cash holdings. We define cash holdings as the natural logarithm of one plus the ratio of cash and cash equivalents to total sales (Jiang and Lie 2016). Table 4 reports the findings when this alternative measure of cash holdings is used. Consistent with the main results reported in Table 3, we find that the coefficient on  $C\_CASH_{t-1}$  is positive and statistically significant at the 1% level. These findings suggest that our findings are not sensitive to the measure of cash holdings used.

**Table 4** Alternative measure of cash holdings

	<i>CASH5</i>
<i>C_CASH<sub>t-1</sub></i>	<b>0.338***</b> (5.33)
<i>S_GO<sub>t-1</sub></i>	0.029*** (5.18)
<i>S_FS<sub>t-1</sub></i>	0.017*** (3.50)
<i>S_BL<sub>t-1</sub></i>	-0.396*** (-12.02)
<i>S_CF<sub>t-1</sub></i>	-0.078* (-1.76)
<i>S_CFV<sub>t-1</sub></i>	-0.076* (-1.72)
<i>S_CAPEX<sub>t-1</sub></i>	-0.745*** (-6.16)
<i>S_NWC<sub>t-1</sub></i>	-0.300*** (-6.60)
<i>S_RD<sub>t-1</sub></i>	0.291*** (20.47)
<i>S_PAYOUT<sub>t-1</sub></i>	-0.073*** (-5.50)
<i>S_LNAGE<sub>t-1</sub></i>	-0.040*** (-4.23)
<i>S_RATED<sub>t-1</sub></i>	-0.047*** (-2.96)
<i>C_GO<sub>t-1</sub></i>	0.009* (1.81)
<i>C_FS<sub>t-1</sub></i>	0.001 (0.11)
<i>C_BL<sub>t-1</sub></i>	0.028 (0.66)
<i>C_CF<sub>t-1</sub></i>	-0.019 (-0.18)
<i>C_CFV<sub>t-1</sub></i>	-0.196 (-1.30)
<i>C_CAPEX<sub>t-1</sub></i>	-0.167 (-1.31)
<i>C_NWC<sub>t-1</sub></i>	0.028 (0.63)
<i>C_RD<sub>t-1</sub></i>	-0.040 (-0.84)
<i>C_PAYOUT<sub>t-1</sub></i>	-0.002 (-0.12)
<i>C_LNAGE<sub>t-1</sub></i>	0.003 (0.22)
<i>C_RATED<sub>t-1</sub></i>	0.020 (0.85)
<i>Constant</i>	0.285*** (3.64)
Year fixed effects	Yes
Industry fixed effects	Yes
Observations	7,679
Adjusted <i>R</i> <sup>2</sup>	0.650

This table reports the results of the OLS regressions on the link between suppliers' cash holdings (*S\_CASH<sub>t</sub>*) and those of their major customers (*C\_CASH<sub>t-1</sub>*), as specified by Model (1), for the sample period from 1980 to 2016. Cash holdings are defined as the common logarithm of one plus the ratio of cash and cash equivalents to total sales. Standard errors are clustered by firm in all regressions. Figures in parentheses are *t*-statistics. The variables' definitions are provided in the Appendix B. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 Instrumental variable regressions

	CASH1		CASH2		CASH3		CASH4	
	1 <sup>st</sup> stage (1)	2 <sup>nd</sup> stage (2)	1 <sup>st</sup> stage (3)	2 <sup>nd</sup> stage (4)	1 <sup>st</sup> stage (5)	2 <sup>nd</sup> stage (6)	1 <sup>st</sup> stage (7)	2 <sup>nd</sup> stage (8)
<i>IND_CASH<sub>t-2</sub></i>	0.334*** (12.69)		0.039*** (2.96)		0.394*** (14.37)		0.175*** (8.41)	
<i>C_CASH<sub>t-1</sub></i>		1.135*** (6.64)		7.701*** (2.79)		0.966*** (7.02)		2.040*** (5.44)
<i>S_GO<sub>t-1</sub></i>	-0.001 (-0.54)	0.024*** (6.59)	-0.001 (-0.28)	0.069*** (2.68)	-0.001 (-0.60)	0.019*** (7.03)	-0.001 (-0.46)	0.038*** (5.31)
<i>S_FS<sub>t-1</sub></i>	0.005*** (3.97)	-0.005 (-1.42)	0.008*** (3.12)	-0.075** (-2.36)	0.004*** (3.95)	-0.003 (-1.08)	0.006*** (3.86)	-0.016** (-2.40)
<i>S_BL<sub>t-1</sub></i>	-0.008 (-0.83)	-0.276*** (-11.19)	-0.030 (-1.24)	-0.673*** (-3.05)	-0.006 (-0.86)	-0.220*** (-11.76)	-0.014 (-1.00)	-0.425*** (-8.81)
<i>S_CF<sub>t-1</sub></i>	-0.009 (-0.90)	-0.043 (-1.53)	0.006 (0.17)	-0.448 (-1.58)	-0.008 (-0.96)	-0.029 (-1.42)	-0.009 (-0.53)	-0.111* (-1.84)
<i>S_CFV<sub>t-1</sub></i>	-0.003 (-0.37)	-0.041 (-1.37)	-0.009 (-0.63)	-0.217 (-1.27)	-0.003 (-0.34)	-0.028 (-1.24)	-0.004 (-0.37)	-0.094* (-1.70)
<i>S_CAPEX<sub>t-1</sub></i>	-0.011 (-0.45)	-0.517*** (-7.39)	-0.048 (-0.87)	-1.626*** (-3.24)	-0.010 (-0.49)	-0.392*** (-7.44)	-0.016 (-0.46)	-0.898*** (-6.66)
<i>S_NWC<sub>t-1</sub></i>	0.014 (1.58)	-0.210*** (-7.69)	0.010 (0.45)	-0.732*** (-3.69)	0.011 (1.49)	-0.160*** (-7.83)	0.017 (1.27)	-0.358*** (-6.73)
<i>S_RD<sub>t-1</sub></i>	-0.002 (-0.67)	0.054*** (7.92)	-0.007 (-0.91)	0.431*** (4.92)	-0.001 (-0.38)	0.037*** (7.71)	-0.004 (-0.95)	0.132*** (7.41)
<i>S_PAYOUT<sub>t-1</sub></i>	-0.003 (-0.67)	-0.020** (-2.02)	-0.011 (-1.19)	0.036 (0.43)	-0.002 (-0.61)	-0.017** (-2.19)	-0.006 (-0.98)	-0.021 (-1.11)
<i>S_INNAGE<sub>t-1</sub></i>	-0.001 (-0.53)	-0.016** (-2.51)	-0.007 (-1.16)	-0.021 (-0.41)	-0.001 (-0.38)	-0.012** (-2.50)	-0.003 (-0.83)	-0.026** (-2.12)
<i>S_RATED<sub>t-1</sub></i>	-0.007 (-1.55)	-0.004 (-0.37)	-0.012 (-1.21)	0.079 (0.83)	-0.006 (-1.59)	-0.003 (-0.34)	-0.009 (-1.44)	0.001 (0.07)
<i>C_GO<sub>t-1</sub></i>	0.009*** (4.87)	-0.012*** (-3.28)	0.026*** (4.74)	-0.191** (-2.04)	0.007*** (5.01)	-0.008*** (-3.34)	0.015*** (4.79)	-0.028*** (-2.98)
<i>C_FS<sub>t-1</sub></i>	-0.015*** (-5.42)	0.022*** (4.16)	-0.037*** (-4.76)	0.284*** (2.59)	-0.012*** (-5.53)	0.016*** (4.21)	-0.022*** (-5.15)	0.050*** (3.92)
<i>C_BL<sub>t-1</sub></i>	-0.252*** (-12.10)	0.277*** (4.90)	-0.406*** (-8.20)	3.211*** (2.78)	-0.215*** (-12.68)	0.200*** (4.96)	-0.319*** (-10.68)	0.656*** (4.65)
<i>C_CF<sub>t-1</sub></i>	0.084* (1.79)	-0.138** (-2.08)	0.073 (0.43)	-0.736 (-2.00)	0.071* (1.94)	-0.099** (-2.05)	0.098 (1.26)	-0.287* (-1.79)
<i>C_CFV<sub>t-1</sub></i>	0.366*** (3.56)	-0.532*** (-2.98)	0.791*** (2.87)	-6.494** (-2.10)	0.295*** (3.57)	-0.369*** (-2.96)	0.528*** (3.42)	-1.286*** (-2.92)



Table 5 continued

	CASH1		CASH2		CASH3		CASH4	
	1 <sup>st</sup> stage (1)	2 <sup>nd</sup> stage (2)	1 <sup>st</sup> stage (3)	2 <sup>nd</sup> stage (4)	1 <sup>st</sup> stage (5)	2 <sup>nd</sup> stage (6)	1 <sup>st</sup> stage (7)	2 <sup>nd</sup> stage (8)
$C\_CAPEX_{t,i}$	-0.399*** (-7.87)	0.402*** (3.49)	-0.977*** (-7.02)	7.202** (2.48)	-0.319*** (-7.97)	0.272*** (3.30)	-0.601*** (-7.65)	1.116*** (3.77)
$C\_NWC_{t,i}$	-0.262*** (-11.91)	0.341*** (5.61)	-0.540*** (-9.19)	4.103*** (2.65)	-0.214*** (-12.17)	0.244*** (5.70)	-0.366*** (-11.08)	0.785*** (4.88)
$C\_RD_{t,i}$	0.075*** (5.23)	-0.067*** (-3.08)	0.538*** (5.41)	-4.162*** (-2.27)	0.051*** (4.84)	-0.034*** (-2.59)	0.182*** (5.84)	-0.354*** (-3.65)
$C\_PAYOUT_{t,i}$	-0.025*** (-4.03)	0.001 (0.10)	-0.044*** (-3.28)	0.289* (1.66)	-0.020*** (-4.19)	-0.002 (-0.23)	-0.033*** (-3.78)	0.032 (1.13)
$C\_LNAGE_{t,i}$	-0.002 (-0.45)	0.000 (0.03)	-0.005 (-0.52)	0.028 (0.34)	-0.002 (-0.49)	0.000 (0.04)	-0.003 (-0.43)	0.001 (0.07)
$C\_RATED_{t,i}$	0.015 (1.58)	0.011 (0.65)	0.010 (0.43)	-0.008 (-0.04)	0.014* (1.86)	0.007 (0.61)	0.014 (1.01)	0.015 (0.41)
Constant	0.307*** (7.10)	-0.155* (-1.80)	0.710*** (6.40)	-4.558** (-2.22)	0.248*** (7.24)	-0.098 (-1.56)	0.450*** (6.89)	-0.541** (-2.48)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	7,679	7,679	7,679	7,679	7,679	7,679	7,679	7,679
Exogeneity test								
<i>Anderson-Rubin F-test</i>	51.586		20.748		55.678		38.228	
<i>p-values</i>	0.000		0.000		0.000		0.000	
<i>Kleibergen-Paap rk Wald statistic</i>	127.788		9.690		145.003		72.788	
<i>p-values</i>	0.000		0.002		0.000		0.000	
Weak instrument test								
<i>Kleibergen-Paap Wald F statistic</i>	161.058		8.788		206.504		70.668	

This table reports the results of the two-stage regressions on the link between suppliers' ( $S\_CASH_t$ ) and their major customers' ( $C\_CASH_{t-1}$ ) cash holdings, as specified by Model (1), for the sample period from 1980 to 2016, using four different measures of cash holdings. In the first-stage regressions, we regress customers' cash holdings ( $C\_CASH_{t-1}$ ) on the two-year-lagged average cash holdings of the customers' industry ( $IND\_CASH_{t-2}$ ) and a full set of control variables which are used in the baseline regressions. We use the predicted values of  $C\_CASH_{t-1}$  obtained from the first stage in the second-stage regressions. We also report the statistics and  $p$ -values of the tests for the exogeneity of the instrumental variables, underidentification, and weak instruments. Standard errors are clustered by firm in all regressions. Figures in parentheses are  $t$ -statistics. The variables' definitions are provided in the Appendix B. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

More importantly, although our baseline regressions include year and industry fixed effects and use lagged values of major customers' cash holdings, we are concerned that several endogeneity problems, especially unobserved omitted variables, may cause biases in our findings. To deal with the problem of unobserved omitted variables, we use an instrumental variable approach. We are aware that a valid instrumental variable must satisfy the relevance condition, that is, it must be correlated with the main dependent variable, and the exclusion restriction condition, that is, it must not be correlated with the error term (Larcker and Rusticus 2010). Similarly to Dhaliwal et al. (2016), we use the average cash holdings in the industries of the major customers as the instrumental variable. Specifically, our instrumental variable is the two-year-lagged value of the average cash holdings of all firms with the same three-digit SIC code as our major customers, excluding our major customers. We argue that the customer industries' average cash holdings satisfy the relevance condition as they reflect industry practices, thus being highly correlated with the major customers' cash holdings. Also, we believe that the exclusion restriction condition is well satisfied since the customer industries' average cash holdings are unlikely to correlate with the error term after controlling for suppliers' firm-specific determinants of cash holdings, especially when lagged by two years.

Table 5 reports the findings when using the instrumental variable approach. For each measure of cash holdings, we report the first- and second-stage regression results. In the first-stage regression, where we regress  $C\_CASH_{t-1}$  on the two-year-lagged customer-industry average cash holdings ( $IND\_CASH_{t-2}$ ) and control variables, we find evidence that the coefficients on  $IND\_CASH_{t-2}$  are positive and statistically significant at the 1% level across all measures of cash holdings.

We perform several tests to check the validity of our instrumental variables. The Anderson-Rubin  $F$  test for endogenous regressors rejects the null hypothesis that the customer-industry average cash holdings are themselves endogenous. Also, the Kleibergen-Paap  $rk$  Wald statistic and the Kleibergen-Paap Wald  $F$  statistic show that underidentification and weak instruments are not a major concern. In the second-stage regressions, we use the predicted values of  $C\_CASH_{t-1}$  obtained from the first-stage regressions and find that the coefficients on  $C\_CASH_{t-1}$  are still positive and statistically significant. As further robustness checks, we use a different instrumental variable, three-year-lagged average cash holdings, and then use two instrumental

variables, that is, both the two-year-lagged and three-year-lagged values together. We find that the results (untabulated) are qualitatively unchanged. Taken together, the evidence from the instrumental variable approach suggests that customers' cash holdings positively affect those of their suppliers.

Next, to rule the concern that our main results may be influenced by time-invariant supplier and customer-supplier pair heterogeneity, we re-estimate Model (1) using fixed-effects regressions. The (untabulated) results show that the coefficients on major customers' cash holdings in both the firm fixed-effects regressions and the customer-supplier relationship (or pair) fixed-effects regressions are statistically significant. Such results indicate that the cash-holdings link between the two parties is unlikely to be influenced by either supplier or customer-supplier relationship fixed effects.

Also, to eliminate the impact of observable confounding factors which may affect both the dependent (*S\_CASH*) and independent (*C\_CASH*) variables, we follow Gow et al. (2016) and Shipman et al. (2017) and employ the propensity score matching (PSM) approach to match suppliers with high-cash customers (treatments) to those with low-cash customers (controls).<sup>5</sup> The results from the regressions on the propensity-score-matched sample show that the cash-holding link between the two parties is positive and statistically significant at the 1% level. The evidence suggests that the cash-holding link between major customers and their suppliers is unlikely to be affected by confounding factors.

In another robustness check, we mitigate the self-selection problem, wherein cash-rich suppliers may choose to do business with major customers which are also cash-rich, by removing customer-supplier pairs with cash-rich major customers from the sample, and then re-estimating Model (1) using the sample that is left. The results show that the cash-holding link remains economically and statistically significant.

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<sup>5</sup> We create a dummy variable *C\_HighCash*, which is equal to one if the customers' cash holdings are higher than or equal to the median level for all firms, and zero otherwise. We then run a probit regression between *C\_HighCash* and the control variables. Using an odds ratio of having a cash-rich major customer, we match each treated firm with one control firm using nearest-neighbour matching, with a caliper of 0.01 and no replacement.

In our final endogeneity test, we follow previous research (Qiu et al. 2017; Cen et al. 2018; Chu et al. 2019) and perform falsification tests using simulation-based fictitious relationship samples to deal with the concern that unobserved shocks may affect the link between suppliers' and their major customers' cash holdings. In particular, we randomly replace each true supplier (customer) with a fictitious supplier (customer) in the same industry (two-digit SIC code) and with the same size (i.e., same asset quintile) and create a pseudo supplier (customer) sample. In total, we create 2,000 pseudo samples, with more than 15 million fictitious observations. We then run the main regressions specified in Model (1) using these pseudo samples. Consistent with our expectation, the evidence shows that the means of the coefficients on *C\_CASH* have mixed signs and are economically insignificant. Importantly, the percentages of times in which statistically significant and positive coefficients on the independent variable are observed are close to zero, and no coefficient on *C\_CASH* is greater than the corresponding coefficient reported earlier in Table 3, across all four measures of cash holdings. Taken together, the evidence from the pseudo analyses suggests that the cash-holding link between the two parties is unlikely to be fictitious. In brief, although it is impossible to account for all endogeneity issues, the results from our endogeneity tests provide adequate support for the notion that major customers' cash holdings have a positive impact on those of their suppliers.

## **5 Possible channels of the cash-holding link between suppliers and their major customers**

In this section, we investigate possible channels through which customers' cash holdings might affect those of their suppliers. We identify two possible channels - the contagion of financial conditions within the supply chain, and the importance of major customers to their suppliers.

### **5.1 The contagion of financial conditions within the supply chain**

Such contagion could be a channel for the positive cash-holding link between major customers and their suppliers. This is because, when major customers are in a favourable financial condition and have a strong liquidity position, they may be better able to pay and fulfil their purchase commitments to their suppliers. Due to the suppliers' significant reliance on these business

partners for sales, they may be better able to accumulate and retain cash, as a result. In other words, major customers' decisions regarding making or delaying payments do affect their suppliers' cash-holding levels. We therefore conjecture that the impact of major customers' cash holdings on those of their suppliers becomes more pronounced when the former are in a favourable financial condition.

To test this conjecture, we re-run Model (1) using two subsamples - observations in which the major customers are in a favourable financial condition and observations in which they are not. We use three measures to capture the financial condition of the major customers. The first is their deviation from their target cash holdings. When these firms have a cash shortage, that is, their cash-holding levels are below their target levels, they may have less ability to pay and fulfil their purchase commitments to their suppliers. In addition, other competing needs for cash may result in delays in paying their suppliers. In contrast, when major customers have excess cash, that is, their cash-holding levels are above their target levels, they may be better able to pay their suppliers. Also, paying their suppliers more quickly may allow them to maintain favourable relationships with them or obtain early-payment discounts. As a result, we conjecture that the impact of major customers' cash holdings on those of their suppliers becomes more pronounced when the former have excess cash. We define a major customer as having excess (deficit) cash if its cash-holding level in year  $t-1$  is higher than or equal to (lower than) its target cash level in the same year.

The second measure of the major customers' financial condition is the dividend policy. Firms which pay dividends are probably in a favourable financial condition, since they tend to be considered less risky by external investors, and thus have better access to external finance (Bates et al. 2009). In addition, it is likely that, when major customers pay dividends, they will also have sufficient cash to pay and fulfil their purchase commitments to their suppliers. As a result, suppliers whose major customers pay dividends may be in a better position to accumulate and retain cash. We classify major customers as dividend-paying firms if their cash dividends paid to common shareholders in a fiscal year are positive.

Finally, the third measure of the major customers' financial condition is growth opportunities. We argue that firms with more growth opportunities are probably those with more sales potential, thus having a greater demand for the goods or services provided by their suppliers. Consequently,

Table 6 The contagion of financial conditions within the supply chain as a possible channel of the cash-holdings link between the two parties

	CASH1		CASH2		CASH3		CASH4	
<b>Panel A: Major customers' deviations from target cash holdings levels</b>								
<i>C_CASH<sub>t-1</sub></i>	Excess	Deficit	Excess	Deficit	Excess	Deficit	Excess	Deficit
	<b>0.299***</b> (6.17)	<b>0.188**</b> (2.34)	<b>0.362***</b> (2.94)	<b>0.250</b> (1.30)	<b>0.295***</b> (6.57)	<b>0.182**</b> (2.52)	<b>0.317***</b> (4.65)	<b>0.234**</b> (2.13)
Supplier and customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,761	3,918	3,980	3,699	3,789	3,890	3,779	3,900
Adjusted <i>R</i> <sup>2</sup>	0.522	0.537	0.470	0.462	0.522	0.538	0.512	0.521
<b>Panel B: Major customers' dividend payments</b>								
<i>C_CASH<sub>t-1</sub></i>	Yes	No	Yes	No	Yes	No	Yes	No
	<b>0.110**</b> (2.29)	<b>0.043</b> (0.67)	<b>0.195</b> (1.59)	<b>0.118</b> (1.11)	<b>0.106***</b> (4.13)	<b>0.048</b> (0.77)	<b>0.129**</b> (2.00)	<b>0.057</b> (0.79)
Supplier and customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,192	1,487	6,192	1,487	6,192	1,487	6,192	1,487
Adjusted <i>R</i> <sup>2</sup>	0.537	0.505	0.479	0.466	0.533	0.509	0.533	0.496
<b>Panel C: Major customers' growth opportunities</b>								
<i>C_CASH<sub>t-1</sub></i>	More	Fewer	More	Fewer	More	Fewer	More	Fewer
	<b>0.252***</b> (5.35)	<b>0.086</b> (1.29)	<b>0.266**</b> (2.28)	<b>0.088</b> (0.82)	<b>0.262***</b> (6.01)	<b>0.078</b> (1.29)	<b>0.249***</b> (3.79)	<b>0.100</b> (1.18)
Supplier and customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,421	3,258	4,421	3,258	4,421	3,258	4,421	3,258
Adjusted <i>R</i> <sup>2</sup>	0.581	0.466	0.518	0.327	0.577	0.479	0.575	0.417

This table reports the results of the OLS regressions on the link between suppliers' cash holdings ( $S\_CASH_t$ ) and those of their major customers ( $C\_CASH_{t-1}$ ), as specified by Model (1), contingent on the financial condition of their major customers, for the sample period from 1980 to 2016. In Panel A, major customers have excess (deficit) cash if their actual level of cash holdings in year  $t-1$  is higher than or equal to (lower than) their target level of cash holdings in the same year, where target cash holdings are estimated by a fixed-effects regression. In Panel B, major customers pay dividends if their cash dividends to common shareholders in a given year are positive. In Panel C, major customers have more (fewer) growth opportunities if their market-to-book ratios are higher than or equal to (lower than) the median ratio across all firms. Standard errors are clustered by firm in all regressions. Figures in parentheses are *t*-statistics. The variables' definitions are provided in the Appendix B. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

their suppliers can better accumulate and retain cash. It is worth noting that, in this study, growth opportunities do not necessarily indicate financial constraints, given that our sample of major customers, overall, comprises very large, well-established firms. We classify a major customer as having more (fewer) growth opportunities if its market-to-book ratio is higher than or equal to (lower than) the median across all firms.

Table 6 reports the findings on the impact of major customers' financial condition on the cash-holding link between them and their suppliers. Panels A-C present the results for major customers with excess and deficit cash, that pay and do not pay dividends, and that have more and fewer growth opportunities, respectively. Note that the coefficients on the control variables are similar to those reported in Table 3 so we have omitted them to save space. In Panel A, we find consistent evidence across the four measures of cash holdings that the coefficients on  $C\_CASH_{t-1}$  are positive and significant at the 5% level in almost every case. The evidence also shows that the coefficients on  $C\_CASH_{t-1}$  when the major customers have excess cash are relatively greater than those when the customers have deficit cash. For example, the coefficient on  $C\_CASH_{t-1}$  in Column (1) is 59% ( $=0.299/0.188$ ) and hence much greater than that in Column (2). The findings lend strong support to our conjecture that, when major customers are in a favourable financial condition, thus having a greater ability to pay, their suppliers may be in a better position to accumulate and retain cash. We find similar results in Panels B and C. Specifically, the coefficients on  $C\_CASH_{t-1}$  when the major customers pay dividends or have more growth opportunities are generally greater than those when the major customers do not pay dividends or have fewer growth opportunities. Also, the coefficients on  $C\_CASH_{t-1}$  are not statistically significant when the major customers do not pay dividends or have fewer growth opportunities, implying that the impact of the major customers' cash holdings on those of their suppliers is not statistically significant when the former are not in a favourable financial condition.

Taken together, we find robust evidence that major customers' cash holdings have a more pronounced impact on those of their suppliers when the former are in a favourable financial condition. This suggests that the contagion of financial conditions within the supply chain is a possible channel for the cash-holding link between the two parties.

## 5.2 The importance of major customers to their suppliers

Next, we investigate an alternative channel for the cash-holding link within the supply chain. We conjecture that the positive impact of major customers' cash holdings on those of their suppliers becomes relatively more pronounced when the former is considered more important to the latter. For example, when suppliers' sales to their major customers account for a larger proportion of the suppliers' total sales, the major customers are seen as more important to their suppliers and these customers' liquidity positions may have a more significant impact on their business partners' ability to accumulate cash. Similarly, when suppliers have higher levels of customer concentration, meaning that they depend more heavily on a small number of customers for sales and cash, their customers' cash holdings may have a greater influence on their own. Finally, when suppliers and their major customers are from the same industry, it is likely that the two parties will be working with the same types of technologies, which could result in the latter having a greater demand for the former's products and services. For example, Apple has hundreds of suppliers, but the giant's most important suppliers are Qualcomm and STMicroelectronics, which are doing business in the semiconductor industry alongside their huge customer. In such cases, the supplier's ability to accumulate cash may be more dependent on their business partner's liquidity position as the latter accounts for a greater proportion of the former's total sales. In general, we argue that, when customers are considered more important to their suppliers, the cash-holding link within the supply chain will be more pronounced.

To test the above conjecture, we re-run Model (1) using two subsamples - observations in which the major customers are considered more important to their suppliers and those in which they are seen as less important. We use three measures of the importance of major customers to their suppliers, namely, the percentage of the supplier's sales that go to their major customer, the supplier's level of customer concentration, and the similarity in nature of the supplier's and their major customer's businesses. A major customer is considered more important to their supplier if (1) the percentage of their supplier's sales that goes to them is higher than the median level of this percentage across all of the major customer to supplier pairs; (2) the supplier's level of customer concentration is higher than the median across all the supplier firms; or (3) they and their supplier have the same two-digit SIC code.



**Table 7** Major customers' importance to their suppliers as a possible channel of the cash-holdings link between the two parties

	CASH1		CASH2		CASH3		CASH4	
	High	Low	High	Low	High	Low	High	Low
<b>Panel A: Major customers' contributions to their suppliers' total sales</b>								
<i>C_CASH<sub>t-1</sub></i>	<b>0.221***</b> (4.36)	<b>0.171***</b> (3.69)	<b>0.319***</b> (3.27)	<b>0.179</b> (1.39)	<b>0.216***</b> (4.57)	<b>0.175***</b> (4.07)	<b>0.255***</b> (3.88)	<b>0.167***</b> (2.68)
Supplier and customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,841	3,838	3,841	3,838	3,841	3,838	3,841	3,838
Adjusted <i>R</i> <sup>2</sup>	0.553	0.470	0.492	0.378	0.553	0.477	0.543	0.443
<b>Panel B: Supplier's level of customer concentration</b>								
<i>C_CASH<sub>t-1</sub></i>	<b>0.235***</b> (4.67)	<b>0.130***</b> (2.78)	<b>0.372***</b> (3.34)	<b>0.008</b> (0.12)	<b>0.228***</b> (4.92)	<b>0.141***</b> (3.12)	<b>0.285***</b> (4.13)	<b>0.087*</b> (1.68)
Supplier and customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,844	3,835	3,844	3,835	3,844	3,835	3,844	3,835
Adjusted <i>R</i> <sup>2</sup>	0.544	0.470	0.483	0.360	0.544	0.477	0.534	0.438
<b>Panel C: Suppliers' and their major customers' industries</b>								
<i>C_CASH<sub>t-1</sub></i>	<b>0.181***</b> (3.06)	<b>0.152***</b> (3.21)	<b>0.305**</b> (2.25)	<b>0.064</b> (0.87)	<b>0.191***</b> (3.49)	<b>0.153***</b> (3.47)	<b>0.206**</b> (2.46)	<b>0.135**</b> (2.29)
Supplier and customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,575	6,104	1,575	6,104	1,575	6,104	1,575	6,104
Adjusted <i>R</i> <sup>2</sup>	0.703	0.436	0.575	0.296	0.708	0.445	0.666	0.391

This table reports the results of the OLS regressions on the link between suppliers' cash holdings (*S\_CASH<sub>t</sub>*) and those of their major customers (*C\_CASH<sub>t-1</sub>*), as specified by Model (1), contingent on the importance of the latter to the former, for the sample period from 1980 to 2016. In Panel A, a major customer makes a high (low) contribution to their supplier's sales if the supplier's sales to that customer divided by the supplier's total sales is greater than or equal to (lower than) the median level of that ratio across all the major customer to supplier pairs. In Panel B, a supplier has a high (low) level of customer concentration if their customer concentration level is higher than or equal to (lower than) the median level for all firms. In Panel C, the two parties operate in the same industry (different industries) if they have the same (different) two-digit SIC code(s). Standard errors are clustered by firm in all regressions. Figures in parentheses are *t*-statistics. The variables' definitions are provided in the Appendix B. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7 reports the results on the impact of the major customers' cash holdings on those of their suppliers, contingent on the importance of the former to the latter. Panels A, B, and C show the findings for the subsamples where the supplier's sales to their major customer as a percentage of their total sales are high and low; where the supplier has high and low levels of customer concentration; and where the supplier and their major customer are from the same or different industries, respectively. In Panel A, we find that the coefficients on  $C\_CASH_{t-1}$  are positive and statistically significant at the 1% level in almost every case. Importantly, the evidence shows that the coefficients on  $C\_CASH_{t-1}$  are greater for the subsample in which the supplier's sales to their major customer account for a larger proportion than for the subsample in which they account for a smaller proportion, of the supplier's total sales. For example, the coefficient on  $C\_CASH_{t-1}$  in Column (1) is 29% ( $=0.221/0.171$ ), much higher than that in Column (2). We find similar results in Panels B and C. In particular, the influence of major customers' cash holdings on those of their suppliers becomes more pronounced when the supplier has a high level of customer concentration and when the two parties are from the same industry.

In an additional analysis, we study whether the cash-holding link between major customers and their suppliers depends on the suppliers' product characteristics, which can have important implications for the strength of the customer-supplier relationship. Following the prior literature, we use the nature of the supplier's products, that is, whether they are durable or non-durable (Iitzkowitz 2013; Lian 2017) and whether they are differentiated or non-differentiated (Giannetti et al. 2011), as measures of the strength of the customer-supplier relationship. Our argument is that, because durable and differentiated products tend to be highly customized to specific customers, it is likely that these customers will maintain longer-term purchase commitments with their suppliers because it will be more difficult for them to find alternative products. From the suppliers' perspective, it will also be difficult for them to find alternative customers if their products or services are highly tailored. In these situations, the customer-supplier relationship between the two parties will be stronger, and the major customer considered more important to their supplier. The results (untabulated) show that the impact of customers' cash holdings on those of their suppliers is more pronounced when the suppliers manufacture durable or differentiated products.

To summarize, we find robust evidence across all four measures of cash holdings that, when major customers are seen as more important to their suppliers, the effect of their cash holdings on those of their suppliers becomes more pronounced. This lends strong support to the notion that the importance of major customers to their suppliers is a possible channel for the cash-holding link within the supply chain.

## **6 Conclusions**

In this paper, we investigate the effect of major customers' cash holdings on suppliers' cash-holding policies. Using a matched sample of customer-supplier relationships in the US, we find evidence in support of the liquidity argument that major customers' cash holdings have a positive impact on those of their suppliers. This impact is statistically significant across four different measures of cash holdings. The findings are robust to various endogeneity problems and other robustness checks. Further analyses show that major customers' cash holdings have a more pronounced impact on those of their suppliers when these customers are in a favourable financial condition, that is, when they have excess cash, pay dividends, and have more growth opportunities. The cash-holding link between the two parties also becomes more pronounced when major customers are considered more important to their suppliers, that is, when suppliers provide a large proportion of their outputs to these major customers, when suppliers have high levels of customer concentration, and when the suppliers and their major customers are from the same industry. The findings suggest that the contagion of financial conditions within the supply chain and the importance of major customers to their suppliers are possible channels for the cash-holding link within the supply chain.

This study contributes to the literature on the determinants of corporate cash holdings and that on customer-supplier relationships. With respects to the corporate cash-holding literature, we are the first to show that, in addition to the established determinants, major customers' cash holdings have a significant impact on those of their suppliers. Regards to the literature on customer-supplier relationships, our study provides additional evidence which confirms the effect major customers' financial conditions and decision making have on those of their suppliers. We extend this literature by showing that the contagion of financial conditions and decision making within the supply chain, apart from the impact of major customers' financial conditions on their

suppliers' financial leverage, stock returns, and bankruptcy risk and the probability of financial distress, is also embodied in the cash-holding link between the two parties.

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## Appendix A: Variable measurement

### Control variables

Consistent with existing studies in corporate cash holdings (Opler et al. 1999; Dittmar et al. 2003; Ozkan and Ozkan 2004; Bates et al. 2009; Venkiteshwaran 2011; Itzkowitz 2013; Jiang and Lie 2016; Lin and Chiu 2017; Nguyen 2019; Amin and Williamson 2020), we control for several important supplier characteristics (*S\_Control*) which jointly determine these firms' levels of cash holdings. The relations between these variables and firms' levels of cash holdings are as follows.

*Growth opportunities (S\_GO)*. This variable is constructed by taking the sum of the market value of equity or market capitalization and the book value of total debt scaled by the book value of total assets. According to the precautionary motive argument, firms' growth opportunities have a positive impact on their levels of cash holdings as high-growth firms are likely to experience more significant costs associated with adverse cash flow shocks and financial distress (Opler et al. 1999; Bates et al. 2009). High-growth firms, due to greater information asymmetries, are more likely to give up positive *NPV* investments when there is a cash shortage and external financing is costly. As a result, they need to hold more cash to grasp growth opportunities more effectively.

*Firm size (S\_FS)*. This is the natural logarithm of the book value of total assets measured in 2010 US dollars (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016). The finance literature suggests a negative link between firm size and cash holdings for several reasons. First, in the spirit of the transaction cost motive argument, large firms should hold less cash as the result of economies of scale, i.e., because they tend to incur lower transaction costs when converting their non-cash financial assets into cash (Miller and Orr 1966). Second, since these firms are less subject to financial distress and information asymmetries, they usually get greater access to external capital markets and there is hence a less prominent need for them to hold cash, as suggested by the precautionary motive argument (Almeida et al. 2004). Finally, according to Sufi (2009), large firms are likely to secure greater access to bank lines of credit, which is a close alternative to cash. These factors together make it less necessary for them to hoard cash.

*Book leverage ( $S_{BL}$ )*. This is the ratio of the sum of long-term and short-term debt to total assets. As leverage is seen as an alternative to cash holdings, there should be an inverse link between this variable and cash holdings (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016).

*Cash flows ( $S_{CF}$ )*. This is operating income before depreciation minus interest expenses, income taxes and total dividends paid, scaled by the book value of total assets. Firms' cash flows and cash holdings may be positively related to each other for two reasons. First, the pecking order view suggests that firms with greater cash flows may be in a better position to accumulate more cash (Myers 1984; Myers and Majluf 1984). Second, these firms tend to have more growth opportunities and should therefore hold more cash (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016).

*Cash flow volatility ( $S_{CFV}$ )*. This variable is constructed by taking the standard deviation of cash flow ( $CF$ ) over a five-year period (from year  $t-6$  to year  $t-1$ ) (Ghaly et al. 2015; Jiang and Lie 2016). The precautionary motive argument suggests a positive link between the variable and cash holdings, since firms with riskier cash flows should accumulate more cash to better cope with potential adverse cash flow shocks in the presence of costly external financing (Opler et al. 1999; Bates et al. 2009).

*Capital expenditures ( $S_{CAPEX}$ )*. This is capital expenditures scaled by the book value of total assets. Its impact on cash holdings needs to be empirically resolved for there are opposing predictions on how this variable may influence cash holdings. In particular, the pecking order view suggests a negative relation between  $CAPEX$  and cash holdings as firms which are making significant investments in assets may experience temporary falls in their cash balances (Riddick and Whited 2009). Also, if capital expenditure results in a rise in fixed assets, which can be used as high-quality collateral, firms' debt capacities may be improved, and they may have less need to hoard cash. In contrast, the trade-off view suggests a positive link between  $CAPEX$  and cash holdings as firms which are making significant  $CAPEX$  may be those with a lot of growth opportunities and hence the need to hold more cash (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016).

*Net working capital ( $S_{NWC}$ )*. This variable is constructed by taking the difference between working capital and cash and cash equivalents scaled by the book value of total assets (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016). According to Bates et al. (2009), since net

working capital consists of highly liquid assets which can be seen as close substitutes for cash, such as accounts receivables and inventories, firms with more *NWC* may hold less cash.

*Research and development expenses (S\_R&D)*. This is research and development expenses scaled by total sales (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016). The trade-off view tends to take these expenses as a close proxy for growth opportunities, which potentially lead to financial distress costs and adverse cash flow shocks. This suggests a positive link between *R&D* and cash holdings. Brown and Petersen (2011) find empirical evidence consistent with this view which shows that, in the presence of financing frictions, firms tend to depend greatly on cash to smooth their *R&D* expenses as adjustments in these expenses, such as the wages of highly skilled technology workers, are costly. On the contrary, the financing hierarchy or pecking order view suggests that these expenses are negatively related to cash holdings. The reason is that firms incurring large amounts of these expenses may temporarily see a fall in cash.

*Dividend payout (S\_PAYOUT)*. This variable is defined to be 1 for firms which pay dividends and 0 otherwise (Opler et al. 1999; Bates et al. 2009; Jiang and Lie 2016). There are also opposing predictions on the link between this variable and cash holdings. According to Fazzari et al. (1988), financially unconstrained firms, which may also be cash-rich, are more likely to pay dividends than financially constrained firms. However, Almeida et al. (2004) and Bates et al. (2009) find that dividend-paying firms tend to hold less cash as they are seen by investors as less risky and therefore receive greater access to external capital markets.

*Credit rating (S\_RATED)*. This is a dummy variable which has a value of 1 if a firm has a non-missing S&P credit rating on long-term debt, and 0 otherwise. Credit ratings, by definition, incorporate credit suppliers' opinions on firms' capacities to meet their financial obligations (Whited 1992; Crouhy et al. 2001; Almeida et al. 2004). It is therefore expected that firms with a credit rating may gain greater access to external capital markets and hence have a less prominent need to hoard cash.

*Firm age (S\_LNAGE)*. This variable is constructed by taking the natural logarithm of the current fiscal year minus the first year listed in the *Compustat* database. Mature firms are likely to have more stable cash flows and hence not need to hold much cash (Opler et al. 1999; Dittmar and Duchin 2010; Pinkowitz et al. 2013).

In addition to the above supplier controls, we follow studies in supply chain finance (e.g., Bauer et al. 2018; Chu et al. 2019) to control for their major customers' main characteristics (*C\_Control*). These customer controls are growth opportunities (*C\_GO*), firm size (*C\_FS*), book leverage (*C\_BL*), cash flows (*C\_CF*), cash flow volatility (*C\_CFV*), capital expenditure (*C\_CAPEX*), net working capital (*C\_NWC*), research and development expenditure (*C\_R&D*), dividend payout (*C\_PAYOUT*), credit rating (*C\_RATED*), and firm age (*C\_LNAGE*), all of which may influence suppliers' cash-holding decisions.

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**Appendix B: Variable definitions**

Variable	Definition
<i>Measures of cash holdings</i>	
<i>CASH1</i>	The ratio of cash and cash equivalents to the book value of total assets.
<i>CASH2</i>	The ratio of cash and cash equivalents to net assets, where net assets are equal to total assets minus cash and cash equivalents.
<i>CASH3</i>	The natural logarithm of one plus the ratio of cash and cash equivalents to total assets.
<i>CASH4</i>	The natural logarithm of one plus the ratio of cash and cash equivalents to net assets, where net assets are equal to total assets minus cash and cash equivalents.
<i>CASH5</i>	The natural logarithm of one plus the ratio of cash and cash equivalents to total sales.
<i>ΔCH</i>	Change in firm's cash-holding level from year $t-1$ to year $t$ .
<i>Deviation</i>	Deviation from firm's target level of cash holdings, defined as the difference between their actual level of cash holdings in year $t-1$ and their target level of cash holdings in year $t$ . Target levels of cash holdings are estimated using Model (1).
<i>Deficit</i>	A dummy variable equal to 1 if firm has a cash deficit i.e., their actual cash-holding level in year $t-1$ is less than their target level of cash holdings in the same year, and 0 otherwise.
<i>Firm characteristics</i>	
<i>BL</i>	Book leverage, which is the ratio of the sum of long-term and short-term debt to the book value of total assets.
<i>CF</i>	Cash flow, which is equal to operating income before depreciation minus interest expenses, income taxes, and total dividends paid, all scaled by total assets.
<i>CFV</i>	Cash flow volatility, which is the standard deviation of cash flow ( <i>CF</i> ) over a five-year period (from year $t-6$ to year $t-1$ ) (Ghaly et al. 2015; Jiang and Lie

2016). We require the sample firms to have at least four non-missing cash flow values to calculate this standard deviation.

*CAPEX* Capital expenditures scaled by total assets.

*CC* Customer concentration, which is calculated based on the Herfindahl-Hirschman Index (Irvine et al. 2016; Lian 2017), as follows:

$$CC = \sum_{j=1}^n \left( \frac{\text{Sales to major customer}_{i,j,t}}{\text{Total sales}_{i,t}} \right)^2$$

where  $i$  represents supplier firm  $i$ ;  $j$  represents major customer firm  $j$ ; and  $n$  is the total number of major customers disclosed by a supplier in year  $t$ . To calculate this index, we keep only major customers which are classified as “COMPANY” in the *Compustat* Segment database (Irvine et al. 2016). We keep non-identifier customers as the calculation of the concentration index does not require customers’ identifiers. By definition,  $CC$  varies from 0 to 1, taking the value 1 if a supplier has only one customer and supplies all of its outputs to that customer.

*FS* Firm size, which is the natural log of total assets measured in 2010 US dollars.

*GO* Growth opportunities, which is the ratio of the market value of total assets to the book value of total assets, where the market value of total assets is the share price times the number of shares outstanding plus long-term and short-term debt.

*NWC* Net working capital, which is working capital minus cash and cash equivalents, all scaled by total assets.

*R&D* Research and development expenses scaled by total sales.

*PAYOUT* Common dividends paid, which is a dummy variable equal to 1 if a firm’s cash dividends paid to common shareholders are greater than 0, and 0 otherwise.

*LNAGE* Firm age, which is equal to the natural logarithm of the current fiscal year minus the first year the firm is listed in the *Compustat* database.

*RATED* Credit rating, which has a value of 1 if the firm has a non-missing S&P credit rating on long-term debt, and 0 otherwise.