CREDIT RISK AND INTER-FIRM DEPENDENCE

by

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DEDICATION

For my Dad

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ABSTRACT

I explore whether inter-firm linkages affect firms' credit risk. After controlling for the endogeneity between a firm's credit risk and its dependence on customers and suppliers, I find that supply-chain relationships affect firms' credit risk. My results indicate firms with exposure to major customers have lower ratings, and the level of firm dependence on major customers is negatively associated with firms' credit ratings. Further, I show when a firm's customers also depend on it, this mitigates the negative effect of dependence on credit risk. Finally, I document a negative association between a customer's reliance on its dependent suppliers and the customer's credit rating. Overall, my results provide insights regarding how inter-firm relationships between corporate customers and suppliers affect credit risk.

CREDIT RISK AND INTER-FIRM DEPENDENCE

1. Introduction

Recent studies that examine supply-chain linkages between firms have shown that firms increase reliance on major customers or suppliers to boost revenue and reduce costs. (Patatoukas (2010), Cowley (1988), Kalwani and Narandas (1995), Matsumura and Schloetzer (2009)). However, in doing so, a firm may become dependent on its customers in the sense that a few customers make up a large part of the firm's sales. This increased dependence can, in turn, increase a firm's risk. The motivation of this study is to examine firms with less diversified customers bases and the corresponding credit risk exposure resulting from these inter-firm linkages.

In terms of the supply-chain, I follow a general definition of credit risk from the Financial Risk Managers Handbook. For the purpose of this study, credit risk is the risk of an economic loss resulting from customers' or suppliers' failure to complete a transaction or the risk of termination of the relationship (Jorion, 2005). A firm that is dependent on its customers has a less diversified customer base, which increases the firm's exposure to the risk of a costly supply-chain disruption. Such risks include the risk of customer default or bankruptcy and the inability of a customer to meet its obligations to the firm. A firm may also be dependent on its suppliers, in the sense that a firm makes its purchases from a few major suppliers. A less diversified supplier-base can also increase a firm's risk exposure to a supply-chain disruption, which includes the risk of supplier bankruptcy. Hence, I hypothesize that firms choose greater exposure to supply-

chain risks due to their relationships with customers and suppliers and, in doing so, increase their credit risk.

Prior work has documented the economic loss resulting from supply-chain disruptions can be large. Firms that announce major supply chain problems experience significant drops in shareholder value of 10.28 percent on average (Hendricks and Singhal (2003), Knight and Pretty (1996)). Further, Hertzel, Li, Officer, and Rodgers (2008) provide large-scale evidence of the association between a firm's performance and the bankruptcy filing of its customers or suppliers. Jorion and Zhang (2009) offer evidence of credit contagion through the supply-chain and the direct effects of counterparty default. These studies identify the importance of considering firm risks associated with supply-chain uncertainty that result from customer or supplier default. However, supply-chain risks can also have important implications for a firm prior to the default or bankruptcy filing of a major customer or supplier.

If firms with major customers have increased supply-chain risk exposure, this risk can be reduced to the extent that firms are in relationships with customers and suppliers that further align their supply-chains. Firms with aligned supply-chains have increased information flow and equitable sharing of risks and costs. For example, customers that build close relationships with suppliers can reduce uncertainty regarding future resources or product technology and can achieve competitive advantages (Fink, Edelman, Hatten, and James (2006), Noordewier, John, and Nevin (1990), Sheth and Sharma (1997)). The reduction in product uncertainty and improved firm performance from building close customer or supplier relationships can reduce supply-chain risk from these inter-firm

linkages. So, if firms that rely on major customers or suppliers are able to effectively increase supply-chain alignment, then these firms would likely have lower credit risk.

I examine whether firms with greater exposure to supply-chain linkages have greater credit risk. To do so, I study firms over the period from 1985 to 2008. I use Standard & Poor's long-term debt rating to proxy for the credit risk of the firm. I explore whether increased exposure to supply-chain risks leads to higher credit risk. Specifically, I test whether firms that depend on a few major customers have lower credit ratings. Similarly, I test whether the extent to which firms depend on these customers leads to higher credit risk, and specifically test whether firms that rely to a greater extent on major customers have lower credit ratings. I also investigate the effect of mutual dependence between firms on risk sharing between customers and suppliers. In particular, I test whether firms with important customers who also depend on them have lower credit risk, and whether customers with increased exposure to their dependent suppliers have higher credit risk.

I am interested in a firm's supply-chain linkages, so I collect data from the Compustat Segments File. This data identifies sales to firms' principle customers in accordance with disclosure requirements. In 1977, the Financial Accounting Standards Board (FASB) enacted a regulation that requires a firm to disclose the level of sales to its principle customer if the sales to that particular customer exceed 10% of total revenue of the firm or if the sales to that customer are considered important by the firm. This data allows me to observe a firm's exposure to its customer-base. I use the proportion of sales to a firm's reported customers to measure a firm's dependence on its major customers. In addition to the percentage of sales to reported customers, I also measure the concentration

of a firm's customer-base using an application of the Herfindahl-Hirschman Index (Patatoukas, 2010). Next, by identifying the principle customers included in the database, I can also determine the extent to which these customers rely on their dependent suppliers. I calculate the total proportion of purchases from dependent suppliers to measure a firm's dependence on its suppliers and use this to study firm risk resulting from increased exposure to supply-chain relationships.

To test the prediction that firms with greater supply-chain risk exposure have higher credit risk, I first examine whether there is a negative association between firms' credit ratings and their exposure to major customers. I include a standard set of firm-specific controls for other factors of business and financial risk. It is important to note that firms' ability to enter into relationships with major customers may be endogenous to their credit risk. Therefore, I use an instrumental variables approach with location specific variables instrumenting for firms' dependence on their major customers. Further, I examine the propensity for firms with major customers to have rating downgrades, and I am interested in whether firms with major customers are more likely to be downgraded. My results indicate firms that report major customers have lower credit ratings. This is consistent with the hypothesis that increased supply-chain exposure leads to increased credit risk.

I also find a negative association between a firm's level of dependence on its major customers and its credit rating. Hence, firms with greater exposure to supply-chain risks, via their dependence on major customers, have higher credit risk. Moreover, I consider additional econometric specifications that include the effects of a firm's

customers' characteristics by including average customer size, industry concentration, and financial status. The average size and industry concentration of a firm's customers do appear to significantly affect a firm's credit rating, while the average financial status of a firm's customers does not. I also use a selection model that takes into account a firm's choice to have rated public debt. Overall, the findings from these additional tests indicate that the negative association between a firm's level of dependence on its major customers and its credit rating is robust to various specifications.

To further investigate the relationship between supply-chain exposure and credit risk, I explore the reverse causality of ratings and supply-chain dependence by using supply-chain dependence as the dependent variable and instrumenting for a firm's credit rating. I find that firms with lower credit ratings are more likely to be suppliers with important customers; however, a firm's credit rating does not appear to significantly affect its proportion of sales to major customers. I also study the association between supply-chain exposure and credit risk at an industry-level. I use industry-level sales from the Bureau of Economic Analysis Benchmark Input and Output Tables to test whether industries with a greater proportion of sales to a few major customer-industries have lower average credit ratings. I find evidence at the industry-level that supply-chain exposure is positively related to credit risk.

Next, I examine firms in relationships with major customers in which one of the customers also depends on the firm. In these particular cases, both the firm and its reported customer are reliant on their supply-chain relationship with one another. Therefore, these firms are likely to have a close relationship with their customers, which

could reduce the risks resulting from inter-firm linkages, as predicted in prior work.[1] I find that for firms with major customers that also depend on them, the negative effect of their exposure to major customers on debt ratings is less pronounced. Hence, my findings are consistent with the prediction that firms in close relationships with major customers can benefit from equitable risk sharing.

I also examine major customers with significant exposure to the dependent suppliers who report them. Customers that depend to a greater extent on the firms that report them are in mutually dependent relationships in the sense that they also rely on their dependent supplier. To determine whether there is risk sharing within these close relationships, I investigate whether there is a negative association between credit ratings of reported major customers and their supply-chain exposure to their dependent suppliers. I address the sample selection problem resulting from the reporting regulation that the supplier's fraction of sales to each customer determines which major customers are reported. My findings indicate firms with greater exposure to their dependent suppliers have lower credit ratings. This is consistent with the hypothesis that there is a risk sharing among firms in mutually dependent relationships.

Finally, I present preliminary evidence on the association between dependence and credit risk by exploring changes in dependence and ratings around supply-chain disruptions. Specifically, I collect data on presidential state of emergency declarations and study the change in both ratings and dependence around these events. In particular, I

[1] See for example, Fink, Edelman, Hatten, and James (2006), Noordwier, John, and Nevin (1990), Sheth and Sharma (1997), Bertrand (1986), Brown, Falk, Fehr (2004), Tonkin (1989)

am interested in the effects of disruptions within industries and across customer-supplier industries. The findings offer some evidence that these events affect firms' supply-chain relationships and, consequently, their credit risk.

In general, this study provides evidence of an association between a firm's credit risk and its relationships with its customers and suppliers. My study makes two main contributions. First, I add to recent literature that documents the contagion of default risk through the supply-chain (Hertzel, Li, Officer, Rodgers (200), Jorion and Zhang (2009)). My findings suggest that having exposure to supply-chain disruptions as a result of a firm's customer-supplier relationships increases a firm's credit risk. This can cause a firm to incur important costs prior to the financial distress of its customers or suppliers.

Second, this study contributes to the more general literature on the impact of customer-supplier relationships on firm characteristics. Prior work finds the risk of customer or supplier default can play an important role in a firm's capital structure and investment decisions (Banerjee, Dasgupta, and Kim (2008), Titman (1984), Kale and Sharur (2007)). My results show the risk of customer or supplier default affects a firm's credit risk. Higher credit risk may have additional indirect effects on a firm's capital structure and investment decisions.

Overall, my results imply that the extent to which a firm depends on its relationships with customers and suppliers can create exposure to costly supply-chain disruptions. Consequently, these risks negatively affect firms' credit risk. This can have important implications since higher credit risk can limit a firm's ability to borrow, attract investors, and can increase contracting costs.

The remainder of the paper is organized as follows: Section 2 discusses prior work and motivates the hypothesis and predictions. Section 3 describes the data. I then present my methodology for firms with major customers in Section 4. I consider the effect of mutually dependent customer and supplier relationships in Section 5. The methodology and results for firms' relationships with dependent suppliers is in discussed Section 6. I explore supply-chain disruptions in Section 7, and Section 8 concludes.

2. Related Literature and Hypothesis Development

2.1 Benefits of Supply-Chain Exposure

In this study, I am interested in exploring how a firm's reliance on its important customers and suppliers impacts the firm's credit risk. Anecdotal evidence suggests that firms recognize the value of establishing and maintaining customer and supplier relationships. For example, in its 2007 annual report, Masco Corp stated, "Our ability to maintain our leadership positions in the markets we serve and to grow the business depends to a large extent upon our success in maintaining our relationships with major customers." Similarly, Home Depot noted in 2005 that, "If we fail to identify and develop relationships with a sufficient number of qualified suppliers, or if our current suppliers experience financial difficulty, our ability to timely and efficiently access products that meet our high standards for quality could be adversely affected." Therefore, maintaining these relationships appears to be important for firm performance.

The value of these customer and supplier relationships has been documented in several recent studies. Examples include Cowley (1988), which examines business units and finds that selling and advertising costs tend to be lower when there are fewer major customers to service. Kalwani and Narandas (1995) find lower service costs, higher repeat sales, cross-selling opportunities, and higher overall effectiveness of selling expenditures for manufacturers in long-term relationships with major customers. Matsumura and Schloetzer (2009) argue that suppliers can achieve cost savings by engaging in collaborative marketing campaigns with their major customers. Fink, Edelman, Hatten, and James (2006) and Noordewier, John, and Nevin (1990) contend that uncertainty regarding future resources or product technology can be reduced if the firm is a major customer. Jackson (1985) argues suppliers may be able to exploit their major customers' reputations and brand names by using them to attract other customers.

Further, Patatoukas (2010) suggests that suppliers with more concentrated customer bases tend to have higher overall profitability. By examining changes in accounting rates of return, Patatoukas (2010) concludes that firms with more concentrated customer bases have significantly lower selling, general, and administrative expense to sales ratios and also have savings in advertising expenses. He argues that collaboration along the supply-chain promotes efficiencies in the form of enhanced working capital management and overall asset base utilization. Overall, evidence in prior work is consistent with the general view that firms take supply-chain initiatives to boost revenue and cut costs (Craighead, et al. (2007), Tang (2006), Wagner and Bode (2006)), which then leads to leaner operations and increased efficiency in a stable environment.

2.2 Costs of Supply-Chain Exposure

Reliance on important customers and suppliers, while leading to the aforementioned benefits, can also tend to make firms more exposed to costly supply-chain disruptions. Mitroff and Alpasan (2003) conclude that only 5% to 25% of Fortune 500 companies are prepared to handle crises or disruptions. Specifically, the authors estimate that a $50 million to $100 million cost impact can be incurred for each day a company's supply-chain network is disrupted. To the extent that firms are affected by shocks caused to their customers or suppliers, these disruptions can propagate through the supply-chain. Moreover, the economic loss associated with these shocks is likely be more important for firms that rely only on a few major customers or suppliers.

Giesecke and Weber (2004) provide a theoretical framework for exploring the risks associated with business-partner relationships. In their model, suppliers and buyers of goods are linked through a chain of obligations, which then allows contagion through the supply chain via the liquidity shocks of a firm's business partners. Simply, when a firm's customers or suppliers experience a liquidity shock they may fail to honor their obligations, which may then cause the firm to have insufficient cash flow. This, in turn, may limit investment and hinder the ability of the firm to meet its own obligations. Moreover, the authors show in their model that liquidity shocks will be propagated because the probability of the firm itself becoming distressed is positively related to the number of the firm's failing business partners. For some degree of failure by a firm's business partners, the firm will eventually exhaust its own liquidity reserves.

In the Giesecke and Weber (2004) model, business partners are modeled in a lattice economy, and relationships are assumed to be symmetric. This means that if a firm relies on a major customer, this customer relies equally back on the firm. In addition, their model treats the existence of the business relationship as exogenous, where firms have some level of "connectedness" to other firms. I further build on the ideas posited by Giesecke and Weber by empirically exploring the degree to which a firm relies on its customer-base and the effect this has on the firm's credit risk. If a firm relies heavily on a few major customers, it is then exposed to the liquidity shocks associated with these customers. Importantly, because exposure to major customers makes up a significant portion of the firm's sales, the firm would likely experience larger losses in the event a major customer fails to meet its obligations.

Although results in Giesecke and Weber (2004) show macro-economic liquidity shocks are of first order importance, they also indicate that the contagion of liquidity shocks across firms in the supply-chain can lead to firm losses. Their results further show losses due to supply-chain relationships are important in the measurement of credit risk because contagion has an important effect on the distribution of losses, or the severity of losses, once they occur.

2.3 Transaction Costs in the Supply-Chain

In addition to the risks associated with large losses, which can be relatively rare, firms can also face risks associated with potential losses resulting from the types of business relationships they have with their customers and suppliers. These transactions

can be broadly separated into three categories (Williamson, 1979). The first is discrete transactions, which typically have well-defined terms, are easily verifiable, and are short-term in nature. The second is long-term transactions, which are typically incomplete contingent claims under uncertainty and are long-term in nature. These transactions also typically involve implicit, or state-dependent, claims. The third is relational transactions, which are defined as long-term transactions that require ex-ante relation-specific investment.

Studies have investigated the costs of these transactions in the form of risk associated with customer-supplier relationships, as well as the costs of mitigating this risk via contracts. As discussed in Hui, Klasa, Yeung (2010), breech of discrete transactions can lead to large supply-chain disruptions, trading losses, and loss of reputation to meet future obligations. Firms with an undiversified customer base are at risk of a costly supply-chain disruption. In regards to long-term transactions, firms face the risk of customer or supplier default. It can be difficult and costly to write state dependent contracts that cover all contingencies of implicit claims in long-term contracts between customers and suppliers. Klein (2005) states that trading parties will choose the arrangement that best mitigates relevant contractual risks at the least cost. Therefore, to the extent that firms enter into arrangements that do not effectively mitigate all contractual risks, higher credit risk may result.

If a customer makes up a large percentage of a firm's sales, the firm's assets can become specific or "dedicated" to the customer (Joskow, 1988). This can be especially true for firms in relationships with customers that produce durable or unique goods

(Titman, 1984). Firms with high levels of research and development are also more likely to make investments that are specific to their customer-supplier relationships (Allen and Phillips, 2000). These assets are costly to redeploy. If customers terminate their relationship through liquidation, bankruptcy, or for some other reason, then firms with specific assets in place face switching costs (Williamson (1987), Titman (1984), Banerjee, Dasgupta, Kim (2008)). Therefore, firms in relational transactions with major customers that make specific investments face additional costs in the event the relationship is terminated. This leads to increased uncertainty about the firm's future assets and increases firm risk.

When a firm's customers are concentrated and contracts are incomplete, ex-post bargaining can arise after the firm has made relationship-specific investments. Macaulay (1963) suggests that relationships between firms tend to be more informal, which can lead to opportunism, and this is especially true for long-term relationships. The risk of opportunistic re-contracting can be mitigated by complete contracts. However, to the extent that firms are not able to write complete contingent contracts, or choose to maintain an informal relationship, they are exposed to ex-post opportunistic re-contracting, and this increases uncertainty about the profitability of the relationship. Hence, firms that depend on major customers and make relationship-specific investments are exposed to the risks of transaction termination and opportunistic re-contracting. These risks should lead firms with major customers to have higher levels of credit risk.

However, firms with a concentrated customer base can manage the risks associated with discrete transactions by ensuring that principle customers and suppliers

have strong reputations for meeting their outstanding obligations. Firms' SEC filings generally highlight both of these reasons as justification for their customer concentration. "Management believes concentrations of credit risk with respect to accounts receivable is limited due to the generally high quality of the company's major customers, as well as the large number and geographic dispersion of smaller customers…"(Kellogg Annual Report, December 31, 2009). Additionally, prior studies have suggested that suppliers and customers place significant emphasis on a firm's reputation for honoring its stakeholders' implicit claims (Klein and Leffler (1981) and Bull (1987)). This suggests that firms may utilize the reputation of their customers and suppliers to mitigate risks involved with relation-specific investment.

2.4 Empirical Evidence

Empirically, studies have focused on the association between firms' default intensities within and across industries. In a recent study, Jorion and Zhang (2010) consider the observed clustering in default correlations of both industrial and financial firms.[2] They measure counterparty risk using trade-credit, where counterparty risk occurs if credit losses increase the probability of default for the creditor relative to other firms. The authors study direct lending between customers and suppliers and find that if a firm extends trade credit to a counterparty that liquidates, the loss in market value is greater than if the counterparty continues to operate under Chapter 11. Consistent with Titman (1984), Jorion and Zhang argue that this difference is due to the loss on the

[2] Other recent papers which study correlated defaults include: Das, Duffie, Kapadia, and Saita (2007), Davis and Lo (2001), Jarrow and Yu, 2001; and Lang and Stulz (1992).

exposure and loss of future business. Additionally, if the counterparty represents a large fraction of the firm's sales, the authors find that the counterparty default creates "substantial market value losses."

Hertzel, Li, Officer, and Rodgers (2008) is the first paper to find large sample evidence of the effect of bankruptcy filings of a firm's customers and suppliers. They find that suppliers experience negative abnormal returns around the bankruptcy filing of a major customer. They also find that customers of filing firms do not experience significant contagion effects, and they attribute this to customers' anticipation of supplier financial distress. Hertzel, Li, Officer, and Rodgers (2008) provide evidence of the movement of a firm's distress across and within industries. They also find negative abnormal returns for customer and supplier industries when the filing firm's industry is experiencing distress. Their findings provide empirical evidence that firms with major customers have a higher likelihood of financial distress in the event of customer bankruptcy or distress.

These prior empirical studies focus on the contagion of bankruptcy specifically, rather than the credit risk in existing customer and supplier relationships. Therefore, the dependence between customers and suppliers is considered exogenous. It is important to note that firms choose these relationships and also to some extent the degree to which they depend on their business partners, which is likely to be endogenous to its propensity to enter financial distress.

2.5 Hypothesis and Predictions

Firms that rely on major customers expose themselves to the risk of a supply-chain disruption, which can cause increased uncertainty regarding future transactions, future performance, and future assets. My primary hypothesis is that firms with higher levels of supply-chain exposure will have greater credit risk. I explore this main hypothesis by making several predictions pertaining specifically to firms' dependence on customers and firms' dependence on suppliers.

A supplier with at least one major customer faces a greater risk of experiencing a large cash flow shock in the event that one of its major customers fails to meet its obligations. In addition, a firm that is relatively more dependent on its major customers is relatively less diversified and will experience a greater liquidity shock compared to a firm that has low levels of dependence on its customers. This leads to the first testable prediction: Firms' reliance on their major customers is positively associated with firm credit risk (Prediction 1).

A successful close relationship with important customers can lead to improved supply-chain alignment, which is characterized by equitable sharing of risks and improved organizational performance. This can also be associated with generous amounts of rent sharing, and improved product quality (Bertrand (1986), Brown, Falk, Fehr (2004), Tonkin (1989)). If a firm is in a mutually dependent relationship, meaning the firm's major customers are also dependent on the firm, the relationship becomes more stable and the risk that the relationship will be terminated is reduced. Therefore, mutual

dependence in the customer-supplier relationship should lead to lower credit risk compared with firms whose dependence is not reciprocated. I investigate customers and suppliers that depend on one another, and make the following prediction: Firms with major customers that are in mutually dependent relationships have relatively lower credit risk (Prediction 2).

Analogously, firms with greater supply-chain exposure due to their relationship with suppliers should have higher risk due to the risk of economic losses associated with liquidity shocks from their business partners or resulting from termination of the relationship. If a firm makes a larger percentage of its purchases from its dependent suppliers, its supplier-base is relatively less diversified and the loss of a dependent supplier can cause a significant supply-chain disruption. Firms that are more reliant on dependent suppliers will be exposed to unexpected supply-chain disruptions. To the extent that a major customer also relies on its dependent supplier, supplier default can be costly for the customer. I similarly explore whether firms reported as major customers that have higher levels of exposure to their dependent suppliers also have higher credit risk.

Further, for these major customers, increasing reliance on their dependent suppliers increases the mutual dependence between itself and its dependent supplier. Thus, higher credit risk as a result of this increased dependence is also evidence of the risk-sharing between major customers and their dependent suppliers. I formulate the following testable empirical prediction: For firms that are major customers, higher levels

of reliance on dependent suppliers are associated with higher levels of credit risk (Prediction 3).

In summary, recent studies of supply-chain relationships between customers and suppliers find firms can increase dependence on major customers to reduce costs and increase profitability. However, having a more concentrated customer or supplier base may also increase a firm's risk exposure to the adverse effects of a supply-chain disruption. The extent to which firms in mutually dependent relationships can mitigate the negative effect of increased risk exposure remains a matter of question. To shed light on these issues, I empirically test how a firm's dependence on itsmajor customers and suppliers affects its credit risk (Predictions 1-3). I allow firm dependence to be endogenously determined and address inherent sample selection issues in the data.

3. Data

3.1. Supplier and Customer Data

I collect Segments Customer Data from the Business Information File of Compustat from 1978 to 2008. The Statement of Financial Accounting Standards No. 14 (SFAS No.14) of the Financial Accounting Standards Board (FASB) requires a firm to disclose sales to any principle customer if the sales to that customer exceeds 10% of the total revenue of the firm or if the sales to that customer are considered important by the firm.[3] I use this data to calculate a firm's exposure to its customers and suppliers. The

[3] In 1997, FASB changed the reporting requirements for firms' operating segments. Under SFAS 131 which supersedes SFAS No. 14, firms are still required to report whether they have a customer that exceeds

dataset includes a firm's gvkey, which I use to identify a firm, and also includes its company name in years that it reports at least one major customer. This data allows me to distinguish two classifications of firms: 1) firms as suppliers with major customers and 2) firms that are reported as a major customer.

The dataset also includes CSALE, which is defined as the reported sales to each major customer. I use this variable to measure the total proportion of a firm's sales to its major customers. Customers are classified in the data with the variable TYPE as government, company, marketplace, etc. I consider sales to domestic, "company" customers because these customers represent domestic corporate inter-firm linkages.[4] The average dependence of a firm on its major customers is the sum of sales to its major customers divided by the firm's total sales. It represents the magnitude of a firm's exposure to a costly supply-chain disruption in a given year and is calculated as:

$$\text{Supplier Dependence on Customers}_{it} = \sum_{j=1}^{J} \frac{\text{Sales}_{ijt}}{\text{Sales}_{it}}$$

Where i represents each supplier, j represents each supplier's major customers, and t represents time in years. Sales_{ijt} is the sales of supplier i to its customer j at time t. It is defined as the variable CSALE in the segments data and represents sales to each major

10% of sales. Overall, the firm-year observations in which customer is considered important to the firm but sales to the customer is less than 10% of firm total sales make up roughly 8% of my final sample.

[4] The data also includes customers with Type=government, marketplace, etc. I am interested in credit risk that flows through corporate firm customer-supplier relationships and so exclude these observations from the calculations of *Supplier Dependence on Customers* and *Customer Base Concentration*.

corporate customer in a given year. Sales_{it} is the total sales for supplier i at time t using the SALE variable from Compustat. I am interested in the fraction of sales to major customers as well as the concentration of a firm's customer base. Therefore, I use a second measure introduced in Patatoukas (2010) to further characterize the extent to which a supplier depends on its major customers. It is computed using an application of the Herfindahl-Hirschman Index in the following way:

$$\text{Customer Base Concentration}_{it} = \sum_{j=1}^{J} \left(\frac{\text{Sales}_{ijt}}{\text{Sales}_{it}} \right)^2$$

Where i represents each supplier, j represents each supplier's major customers, and t represents time in years. The definitions for Sales_{ijt} and Sales_{it} follow from the descriptions above. This measure captures the diversification of a firm's customer base. I use Supplier Dependence on Customers and Customer Base Concentration to test my prediction that firms who depend to a greater extent on major customers have higher credit risk.

In the Segments File, I can also identify the degree to which firms reported as major customers also rely on their dependent suppliers. However, customer names do not follow a clear pattern in the data; they are often incomplete, spelled phonetically, or otherwise abbreviated. Therefore, I identify each customer by manually examining the reported name and comparing it with the names of firms in the full Compustat Fundamentals File. A detailed description of the segments data and my matching

procedure is included in the Appendix. I calculate a firm's reliance on its suppliers in the following way:

$$\text{Customer Dependence on Suppliers}_{jt} = \sum_{i=1}^{I} \frac{\text{Purchases}_{jit}}{\text{COGS}_{jt}}$$

Where j represents each major customer, i represents the number of each customer's dependent suppliers, and t represents time in years. Purchases_{jit} is the purchases for customer j in year t from supplier i, as reported by supplier i in the segments data. COGS_{jt} is the cost of goods sold for customer j in year t and is taken from Compustat. I use Customer Dependence on Suppliers to test my last prediction that higher levels of exposure to a firm's dependent suppliers is associated with higher credit risk

Ideally, I would like to test whether firms who are more dependent on their major suppliers have higher credit risk. However, due to reporting restrictions in the data, I cannot observe firms' major suppliers. The data is such that firms must report reliance on their major customers, but it is not necessary that the customers also be reliant on the reporting firms. Despite this drawback of the data, there is variation in the extent to which customers rely on the suppliers who report them.

3.2. Ratings Data and Firm Characteristics

I use credit rating to represent a firm's overall level of credit risk, which is consistent with the interpretation of credit ratings. For instance, S&P defines ratings as "forward-

looking opinions about credit risk." Standard & Poor's credit ratings express the agency's opinion about, "the ability and willingness of an issuer, such as a corporation or state or city government to meet its financial obligations in full and on time." Additionally, Moody's states, "The ratings are intended to provide investors with an independent, forward-looking assessment of long-term credit risk according to a globally comparable standard." As discussed in Hovakimian, Kayhan, and Titman (2009), there are two important differences between ratings and other measures of firm financial health: 1) ratings aggregate information from various sources and include both soft and hard information, and 2) ratings are forward-looking and may include judgments about the firm's future growth opportunities. Therefore, I collect the S&P Domestic Long-term Issuer Credit Rating from Compustat.[5] I assign the rating to a numeric value each year for all firms in the sample where D=1, CCC- =2, CCC=3, …, AA=24, AA+=25, and AAA=26.[6]

Company attributes including the log of total assets, leverage, and other relevant financial characteristics are calculated by using data from the Compustat Fundamentals File. I exclude firms in financial industries (SIC codes 6000-6999) and utilities (SIC codes 4000-4099, 4500-4599, and 4800-4999) because firms in these industries may have policies in place to meet regulatory requirements for credit risk that differ from other

[5] Firms with debt ratings are different than firms without credit ratings. Firms with ratings are larger, have more tangible assets, are older, and have lower levels of R&D (Barclay and Smith (1995), Faulkender and Petersen (2006), Graham (1996), Graham, Lemmon, Schalheim (1998), Hovakimian, Opler, and Titman, (2001)).

[6] See Kisgen (2006) or Horrigan (1996) for a similar approach. Horrigan (1996) assigns ratings to integers with AAA=1, AA+=2, etc. Kisgen (2006) assigns ratings with AA+=24, AA=23, AA-=21, etc.

publicly traded firms.[7] I exclude firms with headquarters outside of the United States because the geographical coverage of ratings for firms outside of the US has changed overtime (Nickell, Perraudin, and Varatto, 2000). Within a given year, I require firms to have positive values for assets and sales, and non-missing values of all other firm characteristics considered.

Overall, I identify 2,416 unique rated and non-rated suppliers and 529 rated and non-rated customers. The filtering procedures described above yield a sample of 3,300 supplier-firm years with credit ratings available over the period from 1985-2008.[8] In my sample, the average supplier has 1.30 major customers and relies on them for 34% of its annual sales. Supplier's sales to identifiable customers, on average, account for 0.04% of each customer's cost of goods sold. This asymmetry is a result of bias in the data-generating process since regulation does not require that firms report major suppliers.

3.3 Sample Statistics

Table 1 summarizes the data for firms in the sample. The first two columns show the mean and standard deviation for characteristics of firms classified as "suppliers", i.e., firms with at least one major customer. The next two columns contain summary statistics for "customers", i.e., firms reported as a major customer. Finally, statistics for all firms are reported in the last two columns of the table.

[7] Ammer and Packer (2000) find a significant difference in default rates between U.S. industrial and financial firms after controlling for credit rating.

[8] This sample is similar in size to recent literature that considers firm credit ratings during the same time period from 1985 to 2008.

On average, suppliers with major customers have total assets equal to 931.10 million, which is statistically significantly less than firms that do not report major customers (p-value is less than 0.000). They also have significantly less leverage. Leverage levels of suppliers are 0.15 on average while the average for all firms in the sample is 0.28. Suppliers with major customers tend to have lower and more risky operating income. The mean operating income for suppliers is roughly half of that for the full sample of firms, and the coefficient of variation of operating income is almost double that of all firms in the sample. These firms also have significantly higher R&D, 0.06 (p-value is less than 0.000). In terms of their credit risk, suppliers have higher credit risk. A Pearson-chi-squared test shows that the average rating of suppliers (BB+) is significantly lower than firms that do not report any major customers (BBB).

On average, firms reported as major customers are significantly larger than the firms that report them. Major customers have significantly more leverage than their dependent suppliers, i.e., the mean leverage of major customers is 0.18 compared with 0.15 for their dependent suppliers. However, they are significantly less levered on average than firms that are neither suppliers nor reported as major customers. This is consistent with prior work that finds firms in supply-chain relationships have less leverage to induce investment by their business partners (Kale and Sharur, 2007). Firms reported as major customers have high credit ratings on average. However, firms that rely relatively more on their dependent suppliers may still have lower credit ratings relative to firms that have low levels of reliance on their dependent suppliers.

To further explore the relationship between a firm's dependence on its supply-chain linkages and its credit risk, I divide my sample into deciles based on firm dependence level. For firms with major customers, the deciles are determined by their percentage of sales to major customers. Supplier Dependence Deciles for firms that are reported as major customers are determined by the extent that firms rely on their reporting suppliers. Table 2 reports the mean, median, and standard deviation of credit ratings within each decile, with one being the lowest level of dependence and ten being the highest level of dependence. The average credit rating in the lowest dependence decile is higher than the average credit rating in the highest dependence decile. Suppliers' ratings range from 16.16 (BB+) in the lowest decile to 14.76 (BB) in the highest dependence decile. Similarly, major customers' ratings range from 19.97 (A-) in the lowest dependence decile to 18.32 (BBB) in the highest. The table shows a downward trend in ratings as the level of supply-chain dependence increases, which suggest there is a relationship between supply-chain exposure and credit risk.

3.4 Industry Exposure

Next, I investigate the distribution of dependence and credit risk across Fama-French Industries in Tables 3 and 4. In Panel A of Table 3, Column 1 shows the percent of firms within an industry that report at least one major customer. The industry that has the lowest percentage is Wholesale and Retail (FF9) with 14% of firms reporting at least one major customer. The industry that has the highest percentage is Energy (FF4) with 38% of firms reporting at least one major customer. Panel B of Table 3 shows the percent of

firms in an industry that are reported as major customers. In general, a small percentage of firms are reported as major customers ranging from 2% to 8% of firms in an industry.

The mean and standard deviation of firms' supply-chain dependence is reported in Columns 2 and 3, respectively of Table 3. On average firms depend on their major customers ranges from 0.296, in Chemicals and Allied Products (FF5), to 0.413, in Business Equipment (FF6). Whereas, customers depend on their reporting suppliers on average from 0.007 in Chemicals and Allied Products (FF5) to 0.066 in Wholesale and Retail (FF9).

I also calculate the average rating within each industry in the last column for both firms with major customers in Panel A and firms reported as major customers in Panel B. On average, suppliers are rated 15.6, which correspond to BB+. The average rating of suppliers across industries ranges from BB- (14.5) to BBB- (17.2). Customers have higher ratings on average, 19.17 (BBB). Across industries, the ratings of firms reported as major customers range from BBB- (17.81) to A+ (21.9).

In Table 4, I explore industry-level dependence by using the Benchmark Input-Output Tables for 1997 made available by the Bureau of Economic Analysis. This data includes the distribution of industry-level commodities consumed by all customer-industries. Using this data, I identify major customer-industries as those that purchase more than 10% of a supplier-industry's sales. The data does not have asymmetric reporting present in the Compustat Segments File. For that reason, major supplier-industries can be identified as industries that make up more than 10% of a customer-industry's purchases.

Column 1 of Panel A reports the number of major customer industries, on average, within each Fama-French Industry and Panel B shows the number of major supplier-industries on average. In Column 2, I report the average level of supplier-industry dependence on each customer-industry in Panel A and the average dependence of each customer-industry on each supplier-industry in Panel B. Both panels show that overall industries do not tend to depend on each supply-chain linkage to a great extent. Supplying-Industries depend on each customer-industry for less than 5% of their sales on average. Moreover, each supplier-industry appears to have few major customer-industries. Customer-Industries also only depend on each supplier-industry for less than 3% of their sales on average.

Column 4 reports only the dependence on major customer or supplier industries, where a major customer industry and a major supplier industry is defined as an industry that makes up more than 10% of industry sales or industry cost of goods sold respectively. The mean value of dependence on these industries is quite high with supplier-industries in Manufacturing (FF3) having the highest level of dependence of 44.6% on average. In Panel B, the mean value of dependence on major-suppliers is also high, ranging from 22.4% in Business Equipment (FF6) to 41.3% for Other Firms (FF12). Therefore, at an industry-level, there is a wide variation of dependence across and within industries.

4. Firm Dependence on Major Customers

4.1. Methodology

I hypothesize that firms with important customers have higher credit risk due to increased exposure to the adverse effects of a supply-chain disruption. I employ the following regression model.

$$\text{Credit Risk}_{it} = \alpha + \beta_s \text{Supply} - \text{Chain Dependence}_{it} + \beta_X X_{it} + \varepsilon_{it} \quad (1)$$

In Model (1), I proxy for Credit Risk using firms' long term S&P credit rating by assigning it to a numeric value with 26 being the highest (AAA), as discussed in the previous section.

4.2 Control Variables

I include a set (X) of firm-specific control variables. These variables are intended to control for both the business and financial risk of the firm and are also important determinants of credit ratings according to the ratings agencies. The S&P states that "industry risk goes a long way toward setting an upper limit on the rating" (Standard and Poor's, 2001), so I include dummy variables for the Fama and French 48 Industries. I also include the log of total assets because Standards and Poor's explains that firm size can represent diversification and competitive issues. Further, according to Standard and Poor's, profitable firms are better able to attract capital externally, generate equity capital, and withstand business adversity. I control for profitability by including operating

income scaled by total assets. In addition to profitability, rating agencies also consider the volatility of profits. Firms are thought to be more risky if their profits are more volatile. To measure income stability, I calculate the coefficient of variation for operating income. This is defined as the time-series standard deviation of quarterly operating income divided by the time-series average of the operating income absolute values for the previous three years. I include this variable to control for volatility.

In addition, I control for financial risks. Leverage is defined as long-term debt divided by total assets. Results are robust to the use of interest coverage calculated as the log of one plus operating earnings before depreciation divided by interest expense. Interest coverage is not well defined for negative values of earnings, so in these cases, I set interest coverage equal to zero. Subordination ratio is defined as the proportion of debt that has a subordinated status and is included to control for bond characteristics. I also include asset tangibility measured as property, plant, and equipment scaled by total assets. All financial variables are CPI deflated. To mitigate the effect of outliers, all variables are winsorized at the 1^{st} and 99^{th} percentiles.

4.3 Econometric Specification

There is reason to believe variables that measure a firm's dependence on major customers are correlated with the error term. This is due to the fact that the customer's choice of selecting a supplier and the purchasing decision are endogenous to the supplier's credit rating. For example, if a firm is in poor financial health, there may only be a few customers willing to transact with the firm, meaning the firm would be

dependent on these customers due to its financial status. I use an instrumental variables approach to correct for the endogeneity of the dependence measures. I obtain consistent estimates of β_s by choosing instruments that are correlated with firms' dependence on major customers after netting out the effect of the model's control variables. Since a firm's industry is an important determinant of its credit rating, industry-level variables cannot be used to address endogeneity in this model. Instead, I generally exploit variation in firm location and customer-industry location to instrument for a firm's dependence on major customers.

In my analysis, I include an ordered-logit model for the estimation of Model (1), following Kaplan and Urwitz (1979). This allows me to consider the ordinal nature of credit ratings. To estimate the ordinal-logit and address the endogeneity in the model, I use the two stage approach in Smith and Blundell (1986) and Nelson and Olsen (1978) with bootstrapped standard errors. In general, the first stage predicted values are estimated using linear models.[9] Standard errors are clustered by gvkey.

To further mitigate endogeneity concerns, I consider two additional specifications. First, I explore the association between ratings changes and firms' dependence on major customers. I regress Downgrade Dummy, an indicator variable that equals one when a firm has a ratings downgrade and zero otherwise, on Supply-Chain Dependence. I expect firms with greater dependence on their supply-chain linkages to be more likely to have a downgrade in their credit ratings.

[9] First stage results are in the Appendix.

Second, I collect additional data on credit default swap prices and regress this price on two-year lagged values of Supply-Chain. The buyer of a credit default swap receives credit protection, whereas the seller of the swap guarantees the credit worthiness of the product. If a predefined credit event occurs, the protection seller has to pay the notional amount of the swap and receives in exchange the defaulted asset under physical delivery settlement terms. If no credit event occurs, the contract terminates at maturity. This data is collected from Bloomberg and includes the price on 5-year senior-level credit default swaps. CDS prices are usually quoted in basis points. A CDS price of 100 BPS means that the credit insurer will charge 1% each year for covering the risk against default. Independent variables are lagged two periods when the CDS price is the dependent variable, and in all other specifications, the independent variables are lagged one period.

4.4 Supplier Reliance on Important Customers; Binary Variable

The Compustat Segments Data provides a natural classification of firms by allowing the identification of those firms that report at least one major customer. Hence, I first measure Supply-Chain Dependence using this simple classification. Supplier Dummy is an indicator variable that equals one if a firm reports at least one major customer and equals zero otherwise. I test whether firms with at least one major customer have lower ratings by using Model (1) on the full panel of firms with ratings data and other necessary variables available in Compustat.

4.4.1 Instruments

The first instrumental variable used measures the number of available customer-industries in close proximity to the firm's headquarters. To motivate the use of this instrument, my argument is twofold. First, the proximity of firms to their customers is of importance because firms must manage their relationships and monitor their customers. Firms that are closer to major customers likely have lower costs of establishing and monitoring these relationships. Second, if there are less unique customer-industries in close proximity, then a supplier will have less available options, and is more likely to develop a relationship with a major customer. I call this variable Customer Industry Count because it represents the availability of a firm's customers at an industry-level. I argue that this instrument is sufficiently exogenous to a firm's credit rating because it is constructed using supplier industry-level and customer industry-level data.

To construct Customer Industry Count, I first collect data from the Benchmark Input-Output Tables for 1997. For each firm, I identify the corresponding customer industries and available customer-firms within those industries. Next, I collect firm headquarter information for all companies in the customer-industries. To do this, I use the STATE variable from Compustat. Finally, for every firm, I find the number of customer-industries that have at least one customer-firm in the same state as the firm of interest. This measure captures the number of unique customer-industries in a firm's state. [10]

[10] It should be noted the importance of distance probably varies with the nature of the product. In some cases, email and video-conferencing may be sufficient to cement and maintain business relationships. I expect this to be more prevalent in later years of the sample as technological advances became more widely utilized.

In the first stage of my specification, I use a linear probability model to regress Supplier Dummy, which equals one for firms reporting a major customer, on the excluded instrument Customer Industry Count and controls (X). The predicted values from this regression are then included in the second stage in which the dependent variable is Credit Rating, defined as the numeric value of a supplier's Standard and Poor's credit rating with 26 being the highest AAA rating. I also test the strength of my instrument. Given my set of instruments, a Hausman test in the linear model specification indicates that I cannot reject the exogeneity of Supplier Dummy (p-value=0.310). According to the Anderson-Rubin-Wald test and Cragg-Donald F-statistic the instruments are not weak and are valid instruments. Therefore, I report results using both ordinary least-squares and 2-stage least-squares specifications.

It is also important to consider the sample selection resulting from firms' having credit ratings. For example, a firm may choose to not have public rated debt due to its financial status, which would lead to lower ratings. Therefore, I include a specification that addresses this selection problem by using a two-stage Heckman. I instrument for whether or not a firm is rated using four binary variables. The first is an indicator for whether the firm is listed on the NYSE. The next three variables are indicator variables for whether the firm is included in the S&P 500, S&P mid-cap, or S&P small-cap indices. Use of these variables is consistent with recent research that uses firm visibility to determine a firm's propensity to be rated (Faulkender and Petersen, 2006; Hovakimian, Kayhan, and Titman, 2009).

4.4.2 Results

Table 5 shows results from a regression with firm Credit Rating as the dependent variable and Supplier Dummy as the independent variable in ordinary least-squares and ordered-logit regressions. The results indicate that the control variables have the predicted signs. In particular, firms with higher levels of leverage have lower credit ratings as indicated by the negative and significant coefficient, -0.894 (p-value is less than 0.000). Firms that are more profitable and larger have higher ratings, as demonstrated by positive coefficients on operating income and total assets. The estimate for the coefficient of variation of operating income is negative and significant. Thus, firms with more volatile profits have lower credit ratings.

The coefficient on Supplier Dummy, whether a firm has a major customer, in Column 1 is -0.894 (p-value is less than 0.000). The ordered-logit regression coefficient is -0.389 (p-value is less than 0.000). In Column 3, I consider credit ratings using broad rating categories, i.e., AAA, AA, A, BBB, etc. Results show that even with broad rating categories, firms with major customers have lower ratings. I also consider a specification that uses an indicator variable for whether a firm is investment grade of not, i.e., BBB- or greater, as a dependent variable in Column 4. The coefficient on Supplier Dummy is also negative and significant, -0.697 (p-value is less than 0.000). Next, in Column 5, I consider the effect of dependence on credit risk using prices of credit default swaps(CDS) collected from Bloomberg as the dependent variable. I find that firms with at least one major customer have higher CDS prices, which is consistent with higher credit risk.

Overall, these findings suggest that firms with greater exposure to supply-chain disruptions, via their dependence on their major customers, have higher credit risk.

Second-stage results from 2-stage least-squares specifications are presented in Table 6. In Column 1, firms that report at least one major customer have lower credit ratings than firms that do not report at least one major customer. The coefficient on Supplier Dummy is -2.053 and is statistically significant (p-value is 0.033). The ordered-logit regression provides similar results; the coefficient is –1.067 (p-value is less than 0.000). In Column 4, the second stage is a logit regression in which the dependent variable equals one if the firm has a rating above investment grade and zero otherwise. The coefficient on Supplier Dummy is still negative and significant, -0.308 (p-value is 0.040). In Column (5), I use a two-stage Heckman to address the fact that firms choose to have a public debt. The coefficient on Supplier Dummy is negative and significant, -0.723 (p-value is less than 0.000). In general, the association between credit rating and whether a firm has major customers is negative even after instrumenting for a firm's dependence and addressing the selection associated with credit ratings.

Finally, the last column reports the coefficients from a regression with Downgrade Dummy, a binary variable that equals one in the year of a downgrade, as the dependent variable. Again, I use instrumental variables for Supplier Dummy with Customer Industry Count as the excluded instrument in the first stage. I find that firms with major customers are more likely to be downgraded. The coefficient on Supplier Dummy is 0.267 (p-value is 0.010). Therefore, I find that firms with greater exposure to their major customers are more likely to experience a ratings downgrade and have lower

credit ratings in general. These results are consistent with the hypothesis that firms with greater exposure to supply-chain risks have higher credit risk

4.5 Supplier Reliance on Important Customers: Levels

I am interested in whether credit risk is associated with the extent to which a firm is exposed to supply-chain disruptions and the liquidity shocks of its business partners. As previously explained, I can use the Compustat Segments File to construct variables that measure the level of supply-chain exposure, i.e., Supplier Dependence on Customers and Customer Base Dependence. These variables represent a firm's fraction of sales to its major customers and the concentration of a firm's customer base. I expect firms with greater exposure to their major customers to have higher levels of credit risk. To test this, Credit Rating is used as the dependent variable and Supplier Dependence on Customers and Customer Base Dependence are used separately as independent variables for the subset of firms that report at least one major customer.

4.5.1 Instruments

There is reason to believe variables that measure the level of a firm's dependence on its major customers is endogenous to a firm's credit risk. Further, since I am interested in the subset of firms that report major customers, and since this selection is determined by whether firms have a major customer, which is an endogenous variable, sample selection must be addressed. I do so by first regressing an indicator variable for whether a firm reports a major customer on a set of instruments. I then include the inverse mills

ratio in the regression of Credit Rating on the measure of firm dependence. Finally, I use two-stage least-squares to instrument for reliance on major customers (Wooldridge, 2002).

Under this framework, I require two excluded variables. First, I use Industry Customer Count, which is previously defined as the number of customer industries that have at least one customer-firm in the same state as the firm of interest. It captures the number of unique customer-industries in a firm's state. The second excluded instrument provides additional detail on the number of available customers. This variable measures the average number of available customer-firms within a customer-industry that are also in close proximity to the firm. I call this variable Customer Industry Average. It is intended to further capture variation in a firm's available options that can result from consolidation or growth within its customer-industries. Customer Industry Average is calculated as the average number of customer-firms in industries that have at least one customer in the firm's state. For each firm, I identify the customer-industries in the same state as the firm. Next, I compute the average number of firms across these industries. This measure represents the available options within each industry on average that are in close proximity to the firm using supplier-level and customer-level data.

For my set of instruments, a Hausman test in the ordinary least-squares specification indicates that Supplier Dependence on Customers is endogenous (p-value is less than 0.000) and Customer Base Concentration is endogenous (p-value is less than

0.000).[11] I conclude from the Anderson-Rubin-Wald and Cragg-Donald F-statistic that the instruments are somewhat weak in some specifications, but overall are valid instruments.

4.5.2 Results

Table 7 reports ordinary least-squares, ordered-logit, and second stage results. The dependent variable in the second stage, Credit Rating is the supplier's Standard and Poor's credit rating with 26 being the highest AAA rating. Firms with more income variability have lower ratings, as indicated by the negative coefficient on the coefficient of variation for operating income, -1.182 (p-value is less than 0.000). I find firms that depend to a greater extent on identified major customers have lower credit ratings. The coefficients for Supplier Dependence on Customers in Column 1-3 and Customer Base Concentration in Columns 4-6 are negative and significant. After addressing the endogeneity and sample selection, the coefficients are -28.284 (p-value is 0.007) in Column 2 and -29.663 (p-value is 0.040) in Column 5. Economically, this indicates that a 10% increase in a firm's dependence on its major customers is associated with a decrease in credit ratings of 2.6. In general, characteristics that lead to stability and profitability are positively associated with higher ratings, and characteristics that represent future uncertainty including Supplier Dependence on Customers are negatively associated with credit ratings. These findings are consistent with the prediction that firms that depend

[11] This endogeneity test relies on the choice of instruments. With other constructed instruments, such as the average number of firms in only major customers' industries, the Hausman test also strongly rejects the exogeneity of *Supplier Dependence on Customers*

more on their major customers are exposed to additional risks, which are associated with lower credit ratings.

If liquidity shocks are propagated through a supply-chain, the bargaining power between firms, as well as the financial stability of firms, may affect firms' credit risk. In the following two tables, I include additional variables to control for firm size, industry concentration, and other aspects related to firm credit risk and also include the size, industry, and financial health of firms' customers.

I use Supplier Dependence on Customers to represent a firm's exposure to its major customers. Results for specifications that control for a firm's own characteristics are reported in Table 8. First, in Column 1, I control for the level of R&D expenditures. I include a dummy variable that equals one if a firm has R&D levels above the mean value in a given year and equals zero otherwise. This is intended to control for firms that have made more relationship-specific investment and thus, are likely to experience greater losses in the event of customer-default. The coefficient on Supplier Dependence on Customers remains negative, -6.406, and significant (p=0.025).

I include the concentration of a firm's industry in Column 2. The Herfindahl index of an industry is computed using concentration ratios from the 1987, 1992, 1997 and 2002 *Census of Manufacturers* publications. The *Census of Manufacturers* calculates the Herfindahl-index of as industry as the sum of squares on the individual market shares of all companies in an industry or the fifty largest companies in an industry, whichever is lower. I merge this measure with my sample in the following way: HHI measures for 1987 are merged with years between 1985 and 1989, HHI measures for

1992 are merged with observations with years between 1990 and 1994, etc. In this way, each HHI from 1987, 1992, 1997 and 2002 is merged using a five year window including the previous two years and following two years. In addition, I follow methodology in Ali, Klasa, and Yeung (2008) to adjust for concentration across NAICS versus SIC industries. This measure is only available for firms in Manufacturing Industries. However, even with this subset of firms, the coefficient on Supplier Dependence on Customers remains negative and significant. The coefficient on the Herfindahl index, -0.006 (p-value of 0.001), indicates that firms that are in more concentrated industries have lower credit ratings.

I also control for firms' governance and include a governance index in Column 3 of Table 8. The Gompers, Ishi, and Metric governance data is also only available for a subset of firms from 1990 through 2006.[12] I find firms that have a higher Governance Index have higher ratings. This means that firms with less governance have higher credit ratings, which is consistent with recent evidence that increased shareholder governance is associated with increased cost of debt financing (Klock, Mansi, and Maxwell (2005), Ashbaugh-Skaife, Collins, and Lafond (2006).

Finally, in Table 8, I explore the effect of reliance on the U.S. government. I include the fraction of total sales to major government customers as reported in the segments data as type "government." I find that reliance on the U.S. government is associated with higher credit ratings which indicate lower levels of credit risk. This result

[12] This data is kindly provided by Andrew Metric on his website at http://faculty.som.yale.edu/andrewmetrick/data.html

is as expected since it is unlikely the government would default or be unable to meet its obligations, and so cause a supply-chain disruption. However, it should be noted that the results in Column 4 of Table 8 are not derived using two-stage least-squares to address the endogeneity of this reliance.

Table 9 presents results from regressions specifications that include average customer characteristics. In Column 1-6, the coefficient on Supplier Dependence on Customers is negative and significant. I include the average size of a firm's customers in the first column. The coefficient on average customer size is -16.336 (p-value is less than 0.000), which means firms with larger customers also have lower ratings. In Column 2, I include the squared average size of a firm's customers. The coefficient on this variable is positive and significant. I also include the average concentration of a firm's customer industries in Column 3 and the squared average concentration multiplied times 100 in Column 4. The concentration of a firm's customer industries does not appear to materially affect its rating. However, the coefficient on Customer Herfindahl-Index in Column 4 is negative and significant (-0.004, p-value 0.016), which indicates firms with customers in more concentrated industries also have lower credit ratings. Moreover, the association between a firm's credit rating and the concentration of its customers' industries is nonlinear; the coefficient on (Customer Herfindahl-Index)^2 is positive and significant. These findings suggest firms that depend on major customers have significantly less bargaining power than their large business partners and this negatively impacts their credit rating. In Columns 5 and 6, I explore whether the financial condition of a firm's business partners affects its rating and find little evidence that this is the case.

This insignificant coefficient on Customer Z-score could be due to the possibility that customers are significantly more financially stable than their dependent suppliers and so, have little impact on the supplier's financial viability overall.

To summarize, firms that are exposed to the adverse effects of a supply-chain disruption, as a result of their relationships with major customers, have lower credit ratings. Specifically, firms that report major customers have lower credit ratings. Further, the level of firm dependence on major customers is negatively associated with firms' credit rating. These results hold after controlling for endogeneity and sample selection. Examining ratings changes also indicates that supply-chain exposure is likely to result in a ratings downgrade. Overall, I find consistent support for the prediction that firms with more exposure to supply-chain risks resulting from relationships with major customers have higher credit risk.

4.6 Reverse Causality Tests

To examine the association between dependence and firm credit ratings, I now consider the effect of credit ratings on firms' propensity to rely on their supply-chain relationships. The results from this reverse-causality test are reported in Table 10, and first stage results are in the Appendix. In Columns 1 and 2, the dependent variable is an indicator variable for whether a firm reports at least one major customer. In Columns 3 and 4 the dependent variable is a firm's proportion of sales to its reported major customers. Credit Rating, again is numerically assigned with AAA being the highest. In this framework, it is important to instrument for a firm's credit rating and to also consider

the sample selection of rated firms. The list of instruments relies largely on the idea that firms that are well known are likely to face lower costs of introducing public debt. (Faulkender and Petersen (2006) and Hovakimian, Kayhan, and Titman (2009)). Following recent literature, my proxies for firm visibility include an indicator variable for firms traded on the NYSE and three indicator variables for the presence of the firm in the large-cap, mid-cap, and small-cap S&P indexes. I use these variables in first stage regressions. Columns 1 and 3 address the endogeneity of supply-chain reliance and firm credit risk, and Columns 2 and 4 further address the sample selection associated with the study of firms with public debt ratings.

The negative coefficient on Credit Ratings in Column 1 shows that firms with lower ratings are more likely to also be firms that report major customers. This finding suggests firms that are less financially stable are more likely to rely on a few major customers for their sales, possibly because other companies are not willing to transact with these firms due to their financial status. Since the independent variable, credit rating is not visible for firms without ratings, Column 2 reports results that use a first stage regression to address sample selection in ratings. The coefficient on Credit Rating is still negative and significant even after this correction, -0.041 (p-value is less than 0.000). Next, I explore the effect of firm credit rating on its level of dependence. In both Column 3 and 4, the coefficient on credit rating is negative, but statistically insignificant. This holds after controlling for the selection of rated firms. Therefore, after instrumenting for credit ratings, there is little evidence that firms' credit ratings lead to increased dependence on firms' major customers.

To summarize, credit rating appears to be an important consideration for firms seeking to establish major customers in the supply-chain. However, it does not appear to significantly affect the extent to which firms expose themselves to these major customers.

4.7 Industry Analysis

In this section, I explore dependence and credit risk of the supply-chain at the industry-level. This is useful first, because it overcomes endogeneity related to firm level characteristics and resulting dependence in customer-supplier relationships. Second, this methodology provides some evidence of industry wide-exposure and vulnerability that could affect contagion across industries. I use data from the Benchmark Input/Output tables to identify the percent of an industry's sales to particular customer-industries. Next, I calculate the average financial characteristics of firms within each industry using data from Compustat. That is, for each supplier-industry, I observe average characteristics of firms in the industry, the industry's level of dependence on all of its customer-industries, and the average characteristics of firms in each of its customer-industries. I am interested in the extent to which supplier-industries rely on major customer-industries, so the measure of Supply-Chain Dependence is the average industry dependence on customer-industries who make up more than 10% of industry sales. This construction is analogous to the firm-level analysis in the previous section. In regressions, the dependent variable is the industry credit rating, which is the average rating of firms in the industry. The independent variables include industry-level

dependence on an industry's own characteristics, as well as the average characteristics of its customer industries.

Results are presented in Table 11. In Column 1, the independent variables include industry-level Supply-Chain Dependence and an industry's own characteristics. The coefficient on Supply-Chain Dependence is negative and significant, -2.66 (p-value is 0.097). This provides evidence that an industry's reliance on its major customer-industries is inversely related to its credit rating. Column 2 shows coefficients for a regression that includes average customer-industry rating, size, research and development expense, and leverage. Again, the coefficient on Supply-Chain Dependence is negative and significant -4.110 (p-value is 0.057). Both the average level of R&D and leverage of customer-industries affect an industry's own average credit rating. Supplier-industries whose customer-industries have higher leverage have lower credit ratings; the coefficient is -10.064 (p-value is 0.099). Supplier-industries whose customer-industries have higher levels of R&D have higher credit ratings. The coefficient is 11.476 (p-value is 0.075). This finding indicates when customer-industries make relationship-specific investments, industry credit risk is reduced. It is not obvious that this should be the case. If a firm's customer makes relationship-specific investment, a supply-chain disruption causes higher switching costs for the firm. However, this positive and significant coefficient suggests that at the industry-level, relationship-specific investment increases stability in the relationship, and thus reduces credit risk.

In Column 3-6 of Table 11, the regressions include interactions of Supply-Chain Dependence and various industry characteristics. Column 3 includes the interaction of

dependence and the average size of firms in customer-industries. Given the contagion of liquidity shocks through a supply-chain, depending more on stable business partners rather than unstable ones should reduce risk. Consistent with this, the coefficient on the interaction of customer-industry size and industry dependence is positive and significant, 5.975 (p-value is 0.029). Interestingly, the coefficient on the interaction between dependence and industry size in Column 4 shows the industry's own average size does not appear to significantly affect its credit risk.

In addition to considering R&D levels of customer-industries, it is important to also consider the interaction between an industry's own R&D and its dependence level. The variable R&D Interaction is an industry's Supply-Chain Dependence multiplied by an industry's own mean level of R&D. In Columns 5 and 6, the coefficient on R&D Interaction is negative and statistically significant, -20.677 (p-value is 0.033) and -23.566 (p-value is 0.005), respectively. Industries that have high levels of dependence on their major customers and also make high levels of relationship-specific investment have higher credit risk. This seems intuitive given that a firm's assets become specific and so are less able to be reallocated should a major customer default or terminate the relationship. In the last column, I include all interaction terms and customer-industry characteristics. Notably, the coefficient on Supply-Chain Dependence remains negative and significant in all specifications.

In general, these findings suggest that at an industry-level, relatively greater levels of supply-chain exposure lead to lower credit ratings. I find a negative association between an industry's reliance on its major customer-industries and the industries' own

credit ratings. This result holds after considering the effect of average industry characteristics and the characteristics of customer-industries. Moreover, the average R&D levels of an industry as well as the R&D levels of its customer-industries appear to be significantly related to credit risk at an industry-level.

5. Mutual Dependence

5.1. Methodology

I have shown that inter-firm linkages expose firms to risks that are associated with lower credit ratings. However, it is possible customers or suppliers reciprocate this dependence. Prior literature suggests that firms can reduce future uncertainty if they can effectively build relationships with their customers and suppliers (Fink, Edelman, Hatten and James (2006), Noordewier, John and Nevin (1990), Sheth and Sharma (1997)). Mutual dependence in the customer-supplier relationship should lead to higher ratings if the relationship increases financial stability and risks are reduced. I investigate whether customers and suppliers that depend on one another, and thus are more likely to have close relationships, have higher credit ratings.

The nature of the data is such that all customer-supplier relationships that are observed involve suppliers that are dependent on their important customers. I identify customers that reciprocate dependence on their suppliers, by first calculating the degree to which a customer depends on each supplier that reports it as a major customer. This is defined as purchases from each supplier divided by the customer's cost of goods sold. I then calculate the median level that customers depend on individual suppliers across all

customer-supplier relationships. I define an indicator variable Co-dependence which equals one if a firm reports a major customer and the customer's dependence on that supplier is above the median level across all customer-supplier relationships. This variable represents supply-chain relationships that are relatively closer and more mutually dependent. I then include Co-dependence in Model (1). In doing so, I regress Credit Rating on Supplier Dummy, Co-Dependence and firm-specific controls. I also consider how Co-Dependence affects the propensity of a firm's debt to be downgraded.

5.2 Instruments

It is reasonable to believe that both Supplier Dummy, the dummy variable for firms with major customers, and Co-dependence, the dummy variable for mutual dependence, are endogenous to Credit Rating. To instrument for Supplier Dummy, I again use Customer Industry Count, which is the number of unique industries with customers in a firm's state. To instrument for Co-dependence, I use Mean Distance, which is the average Euclidian distance between a firm and all companies in possible customer-industries. I calculate this distance measure using the Benchmark Input-Output tables from the Bureau of Economic Analysis to identify a firm's customer-industries and, thus, all customer-firms therein. I use the state of a firm's headquarters to represent location. Longitudinal and latitudinal information are collected from the U.S. Census Bureau Gazetteer for 1997. Distance is computed using the Haversine formula.[13] I then calculate the mean

[13] The Haversine Formula is used to calculate the distance $d12$ between counties 1 and 2. Distance $d12$ is calculated as $d12 = R\times 2\times\arcsin(\min(1, a))$ where R is the radius of the earth ($\approx$ 6378 kilometers) and $a = (\sin(dlat\ 2))2 + \cos(lat1)\times\cos(lat2)\times(\sin(dlon / 2))2$. In the above expression $dlat = lat2 - lat1$ and $dlon =$

distance across customer-firms each year. I use mean distance because this measure captures the proximity of customers and suppliers, and hence the relative closeness of their relationship geographically.

5.3 Results

Second stage results are presented in Table 12. The first two columns of Table 12 report estimated coefficients from OLS and ordered-logit regressions, and Columns 3 and 4 present estimates using the instruments described above to address endogeneity. In all specifications, Supplier Dummy is negative and significant, which is consistent with findings in Tables 5 and 6 and the prediction that firms with exposure to major customers have lower credit ratings. Co-dependence is positive and significant. In Column 5, the dependent variable is an indicator for whether a firm has investment-grade debt. The coefficient on Supplier Dummy is -0.406 (p-value is 0.057) and the coefficient on Co-dependence is 1.832 (p-value is 0.085). Thus, the negative effect of dependence on major customers on debt ratings is less pronounced if customers also depend on the firm. This finding is consistent with prior work that shows firms can experience reduced uncertainty if they can develop close relationships with their customers.[14]

In the last column of Table 12, I examine whether having major customers affects a firm's change in ratings. In Column 6, the dependent variable is a dummy variable that equals 1 if the firm has a rating downgrade in year (t) and zero otherwise. I use second

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*lon*2 − *lon*1 . Lat1 and lon1 are the latitude and longitude of the first State, and lat2 and lon2 are the latitude and longitude of the second State.

[14] Fink, Edelman, Hatten and James (2006), Noordwier, John and Nevin (1990), Sheth and Sharma (1997)

stage estimates with Customer Industry Count and Mean Distance as my excluded instruments for Supplier Dummy and Co-dependence. Again, I find that firms with major customers are more likely to be downgraded. Also, I find marginal evidence that firms with major customers that are co-dependent have fewer downgrades.

Overall, these results show that firms with increased exposure to supply-chain disruptions have lower credit ratings; however, this negative effect may be mitigated if firms are able to build mutually dependent relationships. In these supply-chain linkages, firms are likely to build close relationships that then increase information sharing and, in doing so, reduce future uncertainty.

6. Customer Reliance on Dependent Suppliers

6.1 Methodology

In addition to studying firms' dependence on customers, I also explore the reliance of major customers on their dependent suppliers. I am interested in determining whether firms with greater exposure to supply-chain risks have greater credit risk, I test whether firms' credit ratings are negatively associated with their level of exposure to identified suppliers. I consider the subset of firms that appear as major customers in the segments data and use purchases from their corresponding suppliers to calculate levels of firm reliance. In Model (2), I regress firm credit rating on the level of firms' dependence on their suppliers.

$$\text{Credit Rating}_{it} = \alpha + \beta_{CDS}\text{Customer Dependence on Suppliers}_{it} + \beta_X X_{it} + \varepsilon_{it} \quad (2)$$

Customer Dependence on Suppliers measures the extent to which a customer relies on its dependent suppliers and is calculated as the sum of purchases from identified suppliers divided by the firm's cost of goods sold. X is the same set of firm-specific control variables used in Model (1).

6.2 Instruments

I can only use the subset of customers that were reported as major customers by at least one supplier. Therefore, I am concerned about a potential sample selection bias due to incidental truncation of the data. I address this by using a first stage regression for whether a firm is reported as a customer. I then include the inverse mills ratio from the first stage regression in the second stage regression of credit rating on my measure for supply-chain exposure.

I propose instruments that are correlated with a firm's propensity to be a major customer. These variables capture variation in a firm's available purchasing options. For every customer firm in my data, I count the number of supplier-industries with at least one company in the customer-firm's state. I call this Supplier Industry Count. Use of this instrument is motivated by the fact that firms in close proximity to their suppliers have a lower cost of managing and monitoring the relationship.[15] The construction of this variable closely follows the analogous procedure for calculating Customer Industry

[15] The importance of distance probably varies with the nature of the product. For some firms, which conduct business using technological advances, distance may not be an important factor in establishing and maintaining business relationships

Count for suppliers. That is, I again make use of the Benchmark Input-Output Tables for 1997 from the Bureau of Economic Analysis. Using the Input-Output industries is useful because in the segments data, I cannot observe all of a firm's suppliers, only those that report the firm as a principle customer. Next, I collect firm headquarter information for all companies in supplier-industries using the STATE variable from Compustat. For every firm, I find the number of supplier-industries that have at least one company in the same state as the major customer of interest. This represents the number of unique supplier-industries in the firm's state.

I use a second instrument that captures the mean number of companies that are available as suppliers for each customer. I call this variable Supplier Industry Average. This is calculated as the average number of supplier-firms in industries that have at least one supplier in the firm's state. For each major customer, I identify supplier-industries in the same state as the firm. Next I compute the mean number of suppliers across these industries. This provides the average available purchasing options that are in close proximity to the customer.

6.3 Results

I employ Model (2) for the subset of firms each year that are reported as a major customer. The independent variable of interest is Customer Dependence on Suppliers, which is the sum of purchases from observed suppliers divided by the firm's total cost of goods sold. I run a first-stage regression using Supplier Industry Count and Supplier Industry Total as excluded instruments to generate the inverse mills ratio. I then use the

inverse mills ratios in second stage regressions. In this framework, I assume Customer Dependence on Suppliers is exogenous. I do so as a result of the challenging task of finding an additional excluded instrument.

The second stage regression results are reported in Column 1-4 of Table 13. The dependent variable, Credit Rating, is major customers' Standard and Poor's numerically assigned credit ratings with 26 being the highest AAA rating. Major customers who are large have higher ratings, as indicated by the positive coefficient on total assets. Customers with higher levels of leverage and more volatile profitability have lower credit ratings. The coefficient on Customer Dependence on Suppliers is negative and significant. In Column 1, the coefficient is -2.961 (p-value is less than 0.000). The results in Column 2 and Column 4 indicate that after controlling for the sample selection problem associated with firms' reporting of major customers, the association between credit rating and supply-chain dependence remains negative and significant. The inverse mills ratio is positive and significant which indicates major customers have higher ratings and is consistent with univariate evidence that these firms are larger and more financially stable than their supply-chain counterparts. Overall, regression estimates offer support for the prediction that firms that rely more on suppliers have lower ratings.

Therefore, firms that are reported as major customers are exposed to supply-chain risks via their inter-firm linkages. The level of firms' dependence on their dependent suppliers is negatively associated with firms' credit ratings after addressing the sample selection associated with being reported as major customers. This is consistent with risk-sharing between major customers and their dependent suppliers.

7. Supply-Chain Exposure and Natural Disasters

In this section, I empirically investigate the association between customer-supplier relationships and firms' credit risk by considering the impact of observable supply-chain disruptions. To explore exogenous shocks to supply-chain relationships, I collect data on declared state of emergencies in U.S. states. Data comes from the Public Entity Risk Institute website. The data was compiled by Richard Sylves and is taken from official disaster declaration information provided to Sylves by the U.S. Federal Emergency Management Agency (FEMA) in 1994, 1997, 2001, 2003, 2005, 2006, and 2008. [16] It includes information on state and county- level disaster declarations as well as declared state of emergencies. The first major disaster included in the data is a Georgia tornado approved for a declaration by President Eisenhower in May 1953. The data includes DATE, which is the day on which the presidential decision on the governor request is announced and includes the day, month, and year of that decision. As Sylves explains, in the vast majority of cases, the president acts on governor requests for declarations of major disasters in a period of days, and sometimes in only hours. However, in a significant number of cases the federal disaster agency is given time (weeks or months) to authenticate losses and establish deservedness. Each disaster is assigned a code that designates the type of disaster including: flood, tornado, tsunami, biological, drought, earthquake, freezing, hurricane, terrorist, chemical, snow/ice, severe storms, toxic substances, fire, etc.

[16] Professor Richard Sylves is in the Department of Political Science and International Relations at the University of Delaware. The data is kindly provided at www.peripresdecusa.org

For the purpose of examining a supply-chain disruption, I focus on events that are Emergency Declarations rather than Major Disaster Declarations because these events tend to be less common and more severe in terms of their geographical scope within a specific U.S. state. I manually collect data that includes the year and state of declared state of emergencies from the Peri-Foundation website for each state. Next, firm location is identified by using the STATE variable from Compustat. Overall, I identify 998 state of emergencies across all 50 states for the time period 1985 through 2008.

I am interested in the effect of these events on inter-firm linkages. Each year, I identify firms in states where an emergency was declared. I then study the impact of this event on the rest of the firms' industries. That is, I examine other companies in an affected firm's industry that were not directly affected by the emergency itself. This is a useful framework for studying the relationship between supply-chain reliance and credit risk because these events are unanticipated and are observable disruptions in the supply-chain. Moreover, it is likely when a firm's industry is affected by a disaster, customers will seek out remaining unaffected suppliers. This shock will likely result in an increase in dependence for firms already reporting major customers.

Panel A of Table 14 includes statistics summarized across events for firms experiencing an industry shock that were not directly affected by the emergency. The mean characteristics in the one-year period before a shock are in the column "Pre" and the one-year period after a shock in the column "Post". The last column of the table shows the change in mean from the pre-to post-period. Means are calculated using the full sample of events and across all firms in affected industries, excluding firms directly

affected by the events. When an industry is impacted by an emergency, firms in the industry that are not in the affected state increase reliance on their major customers from 0.36 to 0.41. The percent of firms with major customers also significantly increases from 0.20 to 0.25. The average credit rating decreases from 16.94 to 16.27. Operating income also significantly decreases, and the variation in operating income increases. Overall, these preliminary results are evidence that firms' supply-chain relationships can be affected by industry shocks, which may lead to additional contagion effects through the supply-chain. The evidence also lends support to my hypothesis that increased exposure to supply-chain disruptions leads to higher credit risk.

Next, I consider the impact of supply-chain disruptions in a firm's customer-industries. It is likely that if a firm has a significant portion of sales to major customers whose industries experience shocks, the firm may be affected to the extent financial distress propagates through the supply-chain. Industries affected by emergencies are identified. Next, I determine which firms have customers in these industries that also do not report a major customer in the affected state. In this way, the sample includes firms whose customers-industries' experienced a shock but whose customers were not directly affected by the event. Results from this analysis are reported in Panel B of Table 14. Overall, firms are not significantly affected by shocks to customer-industries in cases when the shock does not directly affect firms' business partners. Dependence and Credit Rating do not significantly change. Operating income significantly increases, and z-score significantly decreases. This finding provides some evidence of the limits to contagion

effects. Further developing a framework that fully utilizes this unique dataset is planned for future research.

8. Conclusion

In this study, I empirically investigate the association between customer-supplier relationships and firms' credit risk. I hypothesize that firms with greater exposure to supply-chain risks due to their relationships with customers and suppliers will have greater credit risk. After controlling for endogeneity and sample selection, I find suppliers that depend more on their major customers have lower ratings. Specifically, I find firms that report at least one major customer have lower credit ratings. Conditional on reporting a major customer, there is also a negative association between credit ratings and the extent to which firms depend on their major customers. These findings are consistent with increased uncertainty as a result of possible supply-chain disruptions, which can affect future assets, future performance, and future transactions. I also examine whether firms that depend more on observed dependent suppliers have lower ratings. I find some evidence that customers who rely more on their dependent suppliers have lower ratings. Finally, I show when suppliers and customers mutually depend on one another, this reduces the negative association between credit ratings and firms' dependence on major customers.

These results add to our understanding of costs and benefits associated with customer-supplier relationships and findings in prior work. The lower ratings associated with these relationships can lead to higher borrowing costs. Hence, this finding can be

viewed as complementary to prior work which finds that firms with major customers or suppliers have lower leverage (Banerjee, Dasgupta and Kim (2008), Kale and Sharur, (2007), Titman and Wessels (1988)).

APPENDIX A. VARIABLE

Variable	Definition
Altman's Z-score	Performance measured using the following formula 1983-1992: z=0.4*T1 + 2.8*T2 + 11.1*T3 + 0.01*T4 + -0.35*T5 1992-: z=1.2*T1 + 0.6*T2 + 10* T3 + 0.05*T4 + -0.47*T5 Where T1=WCAP/AT, T2=RE/AT, T3=EBITDA/AT, T4=(PRCC_F*CSHO)/(DLC+DLTT), T5=SALE/AT
Asset Tangibility	Net Property, Plant and Equipment/ Total Assets PPENT/AT
Co-Dependence	An indicator variable that equals 1 if a firm has a customer whose dependence back on the firm is greater than the median level of major customers' dependence on their suppliers
Credit Rating	The firm's S&P 500 rating from Compustat with 26 being the highest AAA rating
CSALE	The level of sales firms report to each major customer in the Compustat Segments File
Customer Base Dependence	Squared Sum of sales to major customers divided by the firm's total
Customer Dependence on Suppliers	Sum of purchases from dependent suppliers divided by the firm's cost of goods sold

Variable	Definition
Coefficient of Variation of Operating Income.	This variable controls for the observable part of the firm's past income volatility. It is calculated as CV(OPDBP-DP). That is the time series standard deviation of quarterly operating income divided by the time-series average of the operating income absolute values, for three year period preceding the year in question
Interest Coverage	Log(1+(Operating earnings before depreciation divided by interest expense)) Log values are used since increase in coverage from 100 to 101 is not as large as an increase from 1 to 2. Interest coverage not well defined for negative values of earnings. Thus, for these cases, interest coverage=0. Log(1+(OIBDP/XINT))
Leverage	Long term debt divided by total assets. DLTT/AT
NYSE dummy	This is an indicator variable that equals one if the firm is listed on NYSE, zero otherwise
Profitability	Operating Income/ Total Assets Rating agencies consider profitable firms less risky. According to Standard and Poor's, firms with higher operating margins have greater ability to generate equity capital internally, to attract capital externally and to withstand business adversity (OIDBP-DP)/AT

Variable	Definition
R&D	Firm research and development expense scaled by total assets XRD/AT
S&P Index dummy 1	This is an indicator variable that equals one if the firm is on the S&P 500 and zero otherwise
S&P Index dummy 2	This is an indicator variable that equals one if the firm is on the S&P mid-cap and zero otherwise
S&P Index dummy 3	This is an indicator variable that equals one if the firm is on the S&P small-cap and zero otherwise
Sales (millions)	Annual firm sales
SG&A	Selling and general administrative expense scaled by total assets XSGA/AT
Size	Log of Total Assets; Rating agencies place great importance on size. Big firms are more likely to be well diversified, less concentrated geographically, and more financially flexible. Smaller firms are more likely to be riskier, are more exposed to expensive bank debt log(AT)
Subordinated debt	Is used to control for characteristics of bond contracts. Calculated as the Proportion of long term debt that is subordinated DS/DLTT

Variable	Definition
Supplier Dummy	An indicator variable equal to one in years a firm reports at least one major customer in the Compustat Segments Data
Supplier Dependence on Customers	Sum of sales to major customers divided by the firm's total sales from Compustat

APPENDIX B. DATA

The statement of Financial Accounting Standards No. 14 (SFAS No.14) of the Financial Accounting Standards Board (FASB) requires firms to disclose the sales to principle customers if the sales to that customer exceed 10% of total revenue of the firm or if the sales to that customer are considered important by the firm. This reporting started in 1978. In 1997, SFAS 131 superseded SFAS No. 14. The new regulation affected the reporting of a firm's operating segments. The SEC provides a discussion of the requirements to report customer names, "Since the adoption of SFAS No. 14, GAAP has required disclosure of revenues from major customers. SFAS No. 131 now requires issuers to disclose the amount of revenues from each external customer that amounts to 10 percent or more of its revenue as well as the identity of the segment(s) reporting the revenues. The accounting standards, however, have never required issuers to identify major customers. On the other hand, Regulation S-K Item 101 historically requires naming a major customer if sales to that customer equal 10 percent or more of the issuer's consolidated revenues and if the loss of the customer would have a material adverse effect on the issuer and its subsidiaries. Since we continue to believe that the identity of major customers is material information to investors, we propose to retain this Regulation S-K requirement."

On Compustat, the segments data includes the gvkey and name for supplier-firms in years that they report at least one major customer. It also includes a variable CSALE, which is the sales of a supplier to each major customer. The name of the customer and a

variable for customer type are reported in the data. Customer type (TYPE) includes companies, governments, and marketplaces. Customer names do not follow a clear pattern; they are often incomplete, spelled phonetically, or otherwise abbreviated. For example, Campbell Soup Co is reported by a supplier as "CAMPBL SOUP"

I manually examine each reported customer name and match this firm to the appropriate corresponding name and gvkey from the Compustat Fundamentals File. I only match firms which can be clearly identified. For example, the following two customers appear in the data "CORNERSTONE PRPANE PTNR" and "CORNRSTN". The first can be uniquely identified as CORNERSTONE PROPANE PARTNERS from Compustat. However, there is more than one firm with a name that begins with or includes "Cornerstone". The second customer CORNRSTN cannot be uniquely identified due to lack of clarity. I chose to only match customers which could be uniquely identified, rather than make assumptions as to the identity of these firms. Overall, I identify 887 firms during the period from 1985 to 2008 who also have available data on Compustat, including non-missing values for sales and total assets. Of these customers, the most commonly reported customers include Ford Motor Corp, Wal-Mart Store, Inc., Chrysler, and General Electric Co.

APPENDIX C. FIRST STAGE RESULTS

First Stage Coefficients (1)

First stage regressions using a linear model. The sample consists of rated Compustat firms during the period from 1985 to 2008. The instrument for Supplier Dummy is Customer Industry Count and is the number of unique customer industries in the firm's state. The instruments for Dependence on Customers and Customer Base Concentration is Customer Industry Average defined as the number of firms in customer industries with at least one company in the firm's state and Customer Industry Count. The instrument for Co-dependence is Mean Distance and is the distance of a firm to all companies in customer industries. P-values are in parentheses.

	First Stage Table 6	First Stage Table 7	First Stage Table 7	First Stage Table 12
	Supplier Dummy	Dependence on Customers	Customer Base Concentration	Co-Dependence
Customer Industry Count	-0.003	0.002	-0.0002	-0.0002
	(0.000)	(0.681)	(0.578)	(0.419)
Customer Industry Average		0.001	0.0006	
		(0.100)	(0.068)	
Mean Distance				-0.000002
				(0.010)
Log(total assets)	-0.015	0.008	-0.006	-0.005
	(0.000)	(0.767)	(0.627)	(0.000)
Leverage	0.155	-0.104	0.053	0.053
	(0.000)	(0.670)	(0.686)	(0.000)
Operating Income	-0.010	-0.095	-0.126	0.049
	(0.862)	(0.186)	(0.003)	(0.104)
CV(operating income)	0.029	-0.018	0.005	0.008
	(0.035)	(0.766)	(0.879)	(0.249)
Subordinated debt	0.013	0.036	0.024	-0.008
	(0.422)	(0.184)	(0.131)	(0.356)
Asset Tangibility	-1.03	0.023	-0.072	-0.001
	(0.000)	(0.914)	(0.562)	(0.939)
SG&A		-0.037	-0.090	
		(0.811)	(0.287)	
Industry Dummies	Yes	Yes	Yes	Yes
N	12,755	2403	2403	12,755
F-statistic	55.93	17.86	13.66	12.63
Anderson-Rubin Wald (p-value)	0.023	0.000	0.000	0.010
Cragg-Donald Wald	42.48	2.12	4.61	2.67
Endogeneity Test (p-value)	0.173			0.023

First Stage Coefficients (2)

First stage regressions using a linear model for Table 10, in which the independent variable of interest is firm credit rating. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable in Columns (1) through (4) is firm credit rating, which is numerically assigned with AAA=26. In the second-stage, the dependent variable for Columns (1) and (2) is Supplier Dummy and equals one for the years that a firm reports at least one major customer and equals zero otherwise. The dependent variable in second stage models in Columns (3) and (4) is Supplier Dependence on Customers, defined as the sales to all reported major customers divided by the firm's total sales. In Columns (2) and (4) the inverse mills ratio for an additional first stage regression to address the sample selection of rated firms. The first stage of these models also includes the dependent variable equal to one if the firm is rated and zero otherwise is included. This additional first stage regression for whether a firm is rated is included in Column (5). The instruments for whether a firm is rated and firm rating are indicator variables for inclusion in the NYSE, and inclusion in the three S&P indexes. Industry dummies are included for the Fama and French 48 industries. P-values are in parentheses.

First Stage Coefficients (2 continued)

	Supplier Dummy		Level of Dependence		
	(1)	(2)	(3)	(4)	(5)
	Rating	Rating with Sample Selection	Rating	Rating with Sample Selection	Rated
NYSE Indicator	0.955	0.796	0.985	0.881	0.525
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
S&P 500 Indicator	2.171	2.053	1.593	1.2571	0.928
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
S&P Mid-cap Indicator	0.694	0.572	0.441	0.389	0.120
	(0.000)	(0.000)	(0.002)	(0.007)	(0.030)
S&P Small-cap Indicator	-3.450	-0.401	0.104	0.076	-0.045
	(0.000)	(0.000)	(0.416)	(0.552)	(0.366)
Inverse Mills Ratio		-0.450		-0.272	
		(0.000)		(0.002)	
Log(total assets)	0.577	0.376	0.618	0.475	1.340
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-4.961	-5.957	-3.637	-4.387	5.293
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	6.941	6.461	5.242	4.855	0.945
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CV(operating income)	-1.850	-1.852	-1.286	-1.289	0.031
	(0.000)	(0.000)	(0.000)	(0.000)	(0.589)
Subordinated debt	-1.040	-1.495	-0.562	-0.812	2.281
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Asset Tangibility	0.817	0.791	1.688	1.686	-0.264
	(0.000)	(0.000)	(0.000)	(0.000)	(0.012)
Industry Dummies	Yes	Yes	Yes	Yes	Yes
N	12,187	12,187	2,338	2,338	61,185
F-statistic	458.29	455.51	76.04	74.95	
Anderson-Rubin Wald (p-value)	0.000	0.000	0.000	0.000	
Cragg-Donald Wald	426.50	357.41	55.01	48.25	
Endogeneity Test (p-value)	0.1504	0.1828	0.0159	0.0012	

APPENDIX D. TABLES

Table 1: Descriptive Statistics

The sample covers the period from 1985 to 2008. It includes firms on Compustat with positive, non-missing values for sales and total assets. Credit Ratings are numerically assigned with 1 being the lowest and 26 being the highest using the S&P long-term debt rating from Compustat. Suppliers are identified as firms that report at least one major customer in the Segments Customer Data. Customers are firms that are reported as a major customer in the Segments Data. Leverage is long-term debt divided by total assets. Operating Income, Selling and General Administration Expense, and R&D are scaled by total assets. Total Assets, Sales and Cost of Goods Sold are reported in total levels. For Suppliers, Supply-Chain Dependence is calculated as the sum of sales to major customers divided by firm total sales. Customer-Base Concentration is the sum of the squared proportion of sales to each major customer. For a Customer, Supply-Chain Dependence is the sum of purchases from suppliers that report the firm as a major customer divided by the firm's cost of goods sold.

	Suppliers		Customers		All Firms	
Sample Statistics	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Credit Rating	15.63	3.17	19.17	3.71	16.62	3.69
Total Assets	931.10	3443.93	7426.85	10337.56	4361.63	7201.19
Leverage	0.15	0.169	0.18	0.14	0.28	0.16
Sales	877.53	3087.98	7711.18	9452.84	4267.76	6652.44
Operating Income	0.06	0.19	0.14	0.10	0.13	0.08
Cost of Goods Sold	582.46	2068.29	4970.35	6350.38	2848.94	4538.59
Market Capitalization	974.87	3574.50	7475.00	10312.05	4093.09	7318.50
SG&A	0.34	0.48	0.23	0.18	0.19	0.18
CV(Operating Income)	0.66	0.44	0.38	0.32	0.38	0.32
R&D	0.06	0.10	0.04	0.06	0.02	0.04
Supply-Chain Dependence	0.345	0.262	0.034	0.103		
Customer Base Concentration	0.099	0.142				
Sample of all firms						
Firm-year Observations	18,999		3,529		64,189	
Number of Firms	5,002		887		8,562	
Sample of Rated Firms						
Firm-year Observations	3,300		2,370		12,897	
Number of Firms	941		489		1824	

Table 2: Rating Statistics by Dependence Deciles

The sample covers the period from 1985 to 2008. It includes firms on Compustat with credit ratings available, and positive, non-missing values for sales and total assets. Ratings levels are the S&P long-term rating from Compustat. Suppliers with Major Customers are firms that report at least one major customer in the Segments Customer Data. Major Customers are firms reported as a major customer in the Segments Data. The table shows the mean, median, and standard deviation of Credit Rating across Dependence Deciles. Deciles are formed based on Supply-Chain Dependence with 1 being the least dependent firms and 10 being the most dependent. For Suppliers, Supply-Chain Dependence is calculated as the sum of sales to major customers divided by firm total sales. For a Major Customer, Supply-Chain Dependence is the sum of purchases from suppliers that report the firm as a major customer divided by the firm's cost of goods sold. Financial and utility industries are excluded.

	Ratings for Suppliers with Major Customers			Ratings for Major Customers		
Dependence Deciles	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1 (lowest)	16.16	16.00	3.02	19.97	20.00	3.62
2	16.38	16.00	3.28	19.91	20.00	3.59
3	15.99	16.00	3.31	20.54	21.00	3.74
4	15.80	15.00	3.19	19.89	20.00	3.75
5	15.51	15.00	2.93	19.69	20.00	3.61
6	15.46	15.00	2.85	19.55	20.00	3.46
7	14.96	14.00	3.08	19.38	19.00	3.36
8	14.57	14.00	2.76	19.14	19.00	3.50
9	14.83	14.00	3.33	19.26	19.00	3.79
10 (highest)	14.76	14.00	2.79	18.32	19.00	3.95

Table 3: Ratings and Dependence Firm Level Statistics by Fama French Industry

The sample covers the period from 1985 to 2008. It includes rated firms on Compustat with positive, non-missing values for sales and total assets. The table shows the average rating and distribution of rated customers and suppliers across the Fama and French 12 Industries (financials and utilities are excluded). Suppliers are firms that report at least one major customer in the Segments Customer Data. Customers are firms that are reported as a major customer in the Segments Data. Ratings are numerically assigned with 1 being the lowest and 26 being the highest using the S&P long-term rating from Compustat. For Suppliers, Firm-level Dependence is the sum of sales to major customers divided by the firm total sales. For a Customer, Firm-level Dependence is the sum of purchases from suppliers that report the firm as a major customer divided by the firm's cost of goods sold.

Industry Statistics

Panel A: Suppliers	% of Industry with Major Customers	Mean Firm-level Dependence	Standard Deviation Firm-level Dependence	Mean Rating of Suppliers
FF1. Consumer Non-Durables	0.325	0.307	0.194	15.972
FF2. Consumer Durables	0.368	0.363	0.231	15.904
FF3. Manufacturing	0.295	0.313	0.259	15.890
FF4. Energy	0.380	0.354	0.223	14.529
FF5. Chemicals and Allied Products	0.255	0.296	0.246	17.290
FF6. Business Equipment	0.372	0.413	0.298	15.176
FF9. Wholesale, Retail	0.147	0.366	0.343	15.167
FF10. Healthcare & Medical	0.309	0.412	0.275	16.502
FF12. Other	0.247	0.300	0.253	15.707

Panel B: Customers	% of Industry Reported as a Customer	Mean Firm-level Dependence	Standard Deviation Firm-level Dependence	Mean Rating of Customers
FF1. Consumer Non-Durables	0.042	0.045	0.116	21.107
FF2. Consumer Durables	0.071	0.052	0.068	18.855
FF3. Manufacturing	0.045	0.009	0.011	18.872
FF4. Energy	0.081	0.019	0.044	19.930
FF5. Chemicals and Allied Products	0.079	0.007	0.014	20.529
FF6. Business Equipment	0.051	0.037	0.080	17.815
FF9. Wholesale, Retail	0.087	0.066	0.175	18.265
FF10. Healthcare & Medical	0.049	0.020	0.069	21.936
FF12. Other	0.020	0.024	0.033	18.393

Table 4: Ratings and Dependence Industry-Level statistics by Fama French Industry
The sample covers the period from 1985 to 2008. It includes rated firms on Compustat with positive, non-missing values for sales and total assets. The table shows the average level of dependence at the industry-level across the Fama and French 12 Industries (financials and utilities are excluded). Industry data is from the Benchmark Input-Output Tables and identifies Supplier-Industries in Panel A and Customer-Industries in Panel B. In Panel A, Average Dependence is the average fraction of total industry sales to each customer-industry. Average Dependence on Major Customers is the average dependence on customer-industries that make up more than 10% of industry sales. In Panel B, Average Dependence is the average fraction of total industry purchases from each supplier-industry. Average Dependence on Major Suppliers is the average dependence on supplier-industries that make up more than 10% of industry purchases. Ratings are numerically assigned with 1 being the lowest and 26 being the highest using the S&P long-term rating from Compustat.

Panel A: Suppliers	# Major Industry Customers	Dependence Mean/ All Customers	Dependence Standard Deviation	Dependence Mean/ Major Customers	Average Industry Rating
FF1. Consumer Non-Durables	1.000	0.023	0.093	0.369	17.576
FF2. Consumer Durables	0.000	0.001	0.001		17.059
FF3. Manufacturing	0.660	0.021	0.084	0.446	17.104
FF4. Energy	0.000	0.003	0.002		16.232
FF5. Chemicals and Allied Products	0.000	0.013	0.017		18.050
FF6. Business Equipment	1.000	0.047	0.144	0.292	15.756
FF9. Wholesale, Retail	1.250	0.023	0.082	0.352	16.188
FF10. Healthcare & Medical	0.000	0.005	0.007		17.969
FF12. Other	1.300	0.017	0.067	0.343	15.580

Panel B: Customers	# Major Industry Suppliers	Dependence Mean/ All Suppliers	Dependence Standard Deviation	Dependence Mean/ Major Suppliers	Average Industry Rating
FF1. Consumer Non-Durables	1.250	0.020	0.077	0.320	17.576
FF2. Consumer Durables	0.000	0.000	0.000		17.059
FF3. Manufacturing	1.330	0.024	0.079	0.307	17.104
FF4. Energy	0.000	0.002	0.004		16.232
FF5. Chemicals and Allied Products	0.000	0.007	0.017		18.050
FF6. Business Equipment	0.660	0.021	0.053	0.224	15.756
FF9. Wholesale, Retail	0.800	0.020	0.074	0.314	16.188
FF10. Healthcare & Medical	0.000	0.003	0.002		17.969
FF12. Other	1.000	0.019	0.080	0.413	15.580

Table 5: Firm Dependence on Major Customers and Credit Risk

Pooled regressions using OLS, ordered-logit, and logit models. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable is firm credit rating in Columns (1) and (2). Where credit rating is numerically assigned with AAA=26. In Column (3), the credit rating is numerically assigned using broad rating categories with AAA=9 being the highest. In Column (4) the dependent variable equals one if a firm has a credit rating above investment grade and equals zero otherwise. In Column (5), the dependent variable is the price of the firm's 5-year senior credit default swap security. Supplier Dummy equals one for the years that a firm reports at least one major customer and equals zero otherwise. Industry dummies are included for the Fama and French 48 industries. All independent variables are lagged one year. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)	(5)
	OLS	Ordered-Logit	Broad Rating Categories	Investment Grade Logit	CDS Prices
Supplier Dummy	-0.894	-0.389	-0.359	-0.697	35.505
	(0.000)	(0.000)	(0.000)	(0.000)	(0.045)
Log(total assets)	1.068	0.482	0.553	1.087	-0.825
	(0.000)	(0.000)	(0.000)	(0.000)	(0.926)
Leverage	-6.109	-2.786	-3.088	-5.700	426.46
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	7.900	3.625	3.432	5.189	-149.869
	(0.000)	(0.000)	(0.000)	(0.000)	(0.371)
CV(operating income)	-1.933	-0.916	-1.114	-2.203	306.062
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated debt	-1.481	-0.557	-0.444	-1.919	201.677
	(0.000)	(0.000)	(0.000)	(0.000)	(0.085)
Asset Tangibility	1.267	0.616	0.807	1.494	126.307
	(0.000)	(0.000)	(0.000)	(0.000)	(0.071)
Industry Dummies	Yes	Yes	Yes	Yes	Yes
N	12,755	12,755	12,755	12,755	650
R^2	0.6004		0.5681		0.3701
Pseudo-R^2		0.1806		0.4757	

Table 6: Firm Dependence on Major Customers and Credit Risk

Pooled regressions using 2-stage least-squares specifications. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable is firm credit rating in Columns (1) and (2), and (5). Where credit rating is numerically assigned with AAA=26. In Column (3), the credit rating is numerically assigned using broad rating categories with AAA=9 being the highest. In Column (4) the dependent variable equals one if a firm has a credit rating above investment grade and equals zero otherwise. In Column (6), the dependent variable is an indicator variable for ratings changes that equals one if the firm is downgraded and zero otherwise. Supplier Dummy equals one for the years that a firm reports at least one major customer and equals zero otherwise. In the instrumental variables models in Columns (1) - (4) and (6), Supplier Dummy is computed from predicted values of a linear probability model for whether a firm reports a major customer. In the first stage, Supplier Dummy is regressed on the number of customer-industries in the firm's state. Industry dummies are included for the Fama and French 48 industries. All independent variables are lagged one year. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Instrumental Variables	IV-Ordered Logit	Broad Rating Categories	Investment Grade	Rating Selection	Downgrade Dummy
Supplier Dummy	-2.053	-1.067	-0.941	-0.308	-0.723	0.267
	(0.033)	(0.000)	(0.070)	(0.040)	(0.000)	(0.010)
Log(total assets)	1.052	0.858	0.545	0.131	0.690	0.008
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-5.924	-4.921	-2.995	-0.700	-5.025	0.192
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	7.894	6.553	3.429	0.481	7.208	-0.665
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CV(operating income)	-1.902	-1.632	-1.098	-0.240	-1.772	0.137
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated debt	-1.466	-0.937	0.749	-0.271	-1.217	-0.035
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.023)
Asset Tangibility	1.151	1.276	-0.436	0.170	0.897	0.089
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	12,755	12,755	12,755	12,755	61,181	12,755
Pseudo-R^2		0.1826				15.02
F-statistic	400.50		386.21	439.57		

Table 7: Firm Dependence on Major Customers in Levels and Credit Risk

Pooled regressions using OLS, ordered logit, and instrumental least squares specifications. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable is firm credit rating. Supplier Dependence on Customers is defined as the sales to all reported major customers divided by firm total sales. Customer Base Concentraation is the sum of squared sales to major customers as a percentage of total sales. Instruments are the number of customer industries within the firm's state and the average number of companies in customer industries. All independent variables are lagged one year. Columns (1) and (4), are baseline models which are not corrected for sample selection or the endogeneity of dependence. Columns (2) and (6) correct the model for sample selection and endogeneity and use a linear model in the second stage. Columns (3) and (6) correct the model for sample selection and endogeneity use an ordered logit specification in the second stage with bootstrapped standard errors. Industry dummies are included for the Fama and French 48 industries. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	2SLS Ordered Logit	OLS	2SLS	2SLS Ordered Logit
Supplier Dependence on Customers	-0.786	-28.284	-24.468			
	(0.000)	(0.007)	(0.000)			
Customer Base Concentration				-0.662	-29.663	-27.019
				(0.100)	(0.041)	(0.000)
Log(total assets)	0.891	0.960	0.682	0.894	0.779	0.766
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-2.905	-3.990	-1.789	-2.925	-2.112	-2.208
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	5.631	4.556	3.534	5.789	2.332	2.743
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CV(operating income)	-1.182	-1.258	-0.805	-1.198	-1.092	-1.269
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated debt	-0.604	-0.108	0.693	-0.626	0.022	0.175
	(0.000)	(0.761)	(0.003)	(0.000)	(0.1212)	(0.319)
Asset Tangibility	0.192	0.218	-2.434	0.534	-1.308	-1.027
	(0.166)	(0.625)	(0.000)	(0.141)	(0.244)	(0.012)
SG&A	-0.535	-3.963	-3.411	-0.483	-2.525	-2.267
	(0.322)	(0.069)	(0.000)	(0.376)	(0.036)	(0.000)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	2,403	2,403	2,403	2,403	2,407	2,403
Pseudo-R^2			0.1940			0.1932
F-statistic	58.58	7.06		74.55	22.82	

Table 8: Firm Dependence in Levels with Controls for Firm Characteristics

Pooled regressions using OLS and instrumental least-squares models. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable is firm credit rating. Supplier Dependence on Customers is defined as the sales to all reported major customers divided by firm total sales. Columns (1) - (3) models are corrected for sample selection and the endogeneity of Supplier Dependence on Customers. Instruments are the number of customer-industries within the firm's state and the average number of companies in customer-industries in first stage regressions. High R&D is an indicator variable that equals one in years that the firm level R&D is above the mean R&D. Governance Index is the Gompers, Ishi, Metric Index. Supplier Dependence on the Government is the proportion of total sales that are to customers where type="government." Industry Dummies are included for the Fama and French 48 industries. All independent variables are lagged one year. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)
Supplier Dependence on Customers	-6.406	-4.175	-6.342	-0.881
	(0.025)	(0.011)	(0.040)	(0.042)
High R&D	-1.456			
	(0.059)			
Herfindahl- Index		-0.006		
		(0.001)		
Governance Index			0.128	
			(0.000)	
Supplier Dependence on the Government				0.869
				(0.039)
Log(total assets)	0.930	0.993	1.362	0.967
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-4.016	-3.593	-4.647	-3.730
	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	3.964	5.851	7.667	5.838
	(0.000)	(0.000)	(0.000)	(0.000)
CV(operating income)	-1.271	-1.622	-1.372	-1.414
	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated debt	-0.115	-0.739	0.637	-0.647
	(0.000)	(0.023)	(0.000)	(0.000)
Asset Tangibility	0.229	0.078	1.464	0.580
	(0.610)	(0.922)	(0.039)	(0.112)
Industry Dummies	Yes	Yes	Yes	Yes
N	2,403	1,041	1,478	2,403
F-statistic	26.52	42.40	37.80	62.31

Table 9: Firm Dependence in Levels with Controls for Customer Characteristics

Pooled regressions using OLS. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable is firm credit rating. Supplier Dependence on Customers is defined as the sales to all reported major customers divided by firm total sales. Customer Size is the average total assets of a firm's major customers. Customer Herfindahl-Index is the average HHI measures of a firm's customers' industries. Customer Z-score is the average Z-score of a firm's major customers. Industry Dummies are included for the Fama and French 48 industries. All independent variables are lagged one year. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
Supplier Dependence on Customers	-2.287	-2.406	-2.291	-1.927	-2.617	-2.289
	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)	(0.000)
Customer Size	-16.336	-15.852				
	(0.000)	(0.000)				
(Customer Size)^2		0.110				
		(0.000)				
Customer Herfindahl- Index			-0.002	-0.004		
			(0.955)	(0.016)		
(Customer Herfindahl- Index)^2				0.0001		
				(0.020)		
Customer Z-score					-0.002	-0.000
					(0.453)	(0.929)
(Customer Z-score)^2						0.001
						(0.979)
Log(total assets)	17.476	15.389	1.128	1.163	1.080	1.128
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-3.3755	-3.194	-3.454	-3.577	1.080	-3.457
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	6.454	6.216	6.262	5.982	5.739	6.262
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
CV(operating income)	-1.523	6.216	-1.557	-1.230	-1.244	-1.556
	(0.001)	(0.000)	(0.000)	(0.106)	(0.108)	(0.000)
Subordinated debt	0.513	0.429	0.509	0.306	0.496	0.506
	(0.203)	(0.286)	(0.207)	(0.674)	(0.501)	(0.207)
Asset Tangibility	0.395	0.456	0.392	-1.586	-1.309	0.389
	(0.635)	(0.540)	(0.368)	(0.236)	(0.346)	(0.642)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	485	485	485	485	212	212
R^2	0.6206	0.6267	0.6197	0.6015	0.5926	0.6197

Table 10: Reverse Causality Tests

Pooled regressions using two-stage least-squares and Heckman selection models. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable in Columns (1) and (2) is Supplier Dummy and equals one for the years that a firm reports at least one major customer and equals zero otherwise. The dependent variable in Columns (3) and (4) is Supplier Dependence on Customers, defined as the sales to all reported major customers divided by firm total sales. In Columns (2) and (4) the inverse mills ratio for a first stage regression where the dependent variable equals one if the firm is rated and zero otherwise is included. The instruments for whether a firm is rated are indicator variables for inclusion in the NYSE, and the three S&P indexes. Second state estimates are reported. Credit rating is numerically assigned with AAA=26. Industry dummies are included for the Fama and French 48 industries. All independent variables are lagged one year. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)
	Supplier Dummy	Supplier Dummy with Ratings Selection	Level of Dependence	Level of Dependence Sample-Selection
Credit Rating	-0.039	-0.041	-0.011	-0.009
	(0.000)	(0.000)	(0.170)	(0.313)
Inverse Mills Ratio		-0.008		0.024
		(0.256)		(0.028)
Log(total assets)	0.025	0.022	0.005	0.017
	(0.000)	(0.000)	(0.548)	(0.070)
Leverage	-0.098	-0.124	-0.007	0.066
	(0.005)	(0.006)	(0.880)	(0.303)
Operating Income	0.308	0.309	0.008	0.020
	(0.000)	(0.000)	(0.706)	(0.803)
CV(operating income)	-0.057	-0.060	-0.003	0.009
	(0.000)	(0.000)	(0.966)	(0.648)
Subordinated debt	-0.043	-0.054	0.041	0.064
	(0.009)	(0.006)	(0.063)	(0.011)
Asset Tangibility	-0.033	-0.032	-0.079	-0.083
	(0.140)	(0.150)	(0.028)	(0.023)
Industry Dummies	Yes	Yes	Yes	Yes
N	12,755	12,755	2,407	2,407
F-statistic	27.45	26.87	10.16	10.11

Table 11: Industry Analysis

Pooled regressions using OLS. The sample consists of industries from the Benchmark Input-Output Tables. The dependent variable is the average industry credit rating with AAA being the highest. Supply-Chain Dependence is defined at the industry-level as the sales to all reported major industry-level customers divided by the industry's total sales. Log(total assets), Leverage, Operating Income, CV(operating income), Subordinated debt, and Asset Tangibility are the average value within an industry. Customer Industry Rating, Customer Industry Size, Customer Industry R&D, and Customer Industry Leverage are calculated as the average values for each industry's customer-industries. Interaction terms include Customer Size Interaction, which is an industry's Supply-Chain Dependence multiplied by the average total assets of its customer-industries. Size Interaction, R&D Interaction and Leverage Interaction are defined as an industry's Supply-Chain Dependence multiplied by the average total assets, R&D, and leverage of its own industry, respectively. All independent variables are lagged one year. In linear models, the estimations correct the error structure for clustering at the industry-level. P-values are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
Supply-Chain Dependence	-2.66	-4.110	-29.621	-29.922	-26.930	-28.564
	(0.097)	(0.057)	(0.017)	(0.018)	(0.022)	(0.034)
Customer Size Interaction			5.975	5.900	4.985	5.272
			(0.029)	(0.035)	(0.060)	(0.059)
Size Interaction				0.130	0.499	-0.017
				(0.870)	(0.536)	(0.984)
R&D Interaction					-20.677	-23.566
					(0.033)	(0.005)
Leverage Interaction						16.954
						(0.260)
Log(total assets)	0.906	0.871	0.811	0.728	0.445	0.742
	(0.009)	(0.014)	(0.014)	(0.306)	(0.524)	(0.329)
Leverage	-14.33	-15.415	-14.753	-14.664	-14.582	-23.738
	(0.004)	(0.005)	(0.004)	(0.004)	(0.010)	(0.001)
Operating Income	6.554	4.403	4.695	4.586	5.427	4.769
	(0.004)	(0.520)	(0.455)	(0.462)	(0.373)	(0.493)
CV(operating income)	0.698	1.049	0.845	0.821	0.567	0.241
	(0.764)	(0.693)	(0.726)	(0.736)	(0.825)	(0.930)
Subordinated debt	6.059	6.962	7.408	7.408	8.573	8.903
	(0.041)	(0.036)	(0.011)	(0.011)	(0.005)	(0.010)
Asset Tangibility	-5.165	-4.824	-4.837	-4.788	2.421	3.997
	(0.033)	(0.064)	(0.053)	(0.067)	(0.544)	(0.180)
Customer Industry Rating		0.119				0.068
		(0.664)				(0.808)
Customer Industry Size		-0.439	-2.07	-5.116	-4.895	-5.148
		(0.432)	(0.045)	(0.050)	(0.047)	(0.187)
Customer Industry R&D		11.476			12.148	14.396
		(0.075)			(0.011)	(0.020)
Customer Industry Leverage		-10.064				-0.190
		(0.099)				(0.983)
N	85	85	85	85	85	85
R^2	0.3591	0.386	0.3814	0.3816	0.4094	0.4213

Table 12: Mutual Dependence and Credit Risk

Pooled regressions using OLS ordered logit, and 2SLS regression specifications. The sample consists of rated Compustat firms during the period from 1985 to 2008. The dependent variable is firm credit rating in Columns (1) through (4). Where credit rating is numerically assigned with AAA=26. In Column (5), the dependent variable is an indicator variable for ratings changes that equals one if the firm is downgraded and zero otherwise. In Column (6), the dependent variable is an indicator variable that equals one in years that firms experience a downgrade in credit rating and equals zero otherwise. Supplier Dummy is a dummy variable that equals one if the firm reports at least one major customer. Co-dependence is a dummy variable that equals one if the firm has at least one major customer that also has a high level of dependence on the firm. A major customer has a high level of dependence if its purchases divided by its cost of goods sold is above the median for all customers in a given year. Columns (3) through (6) are second stage regressions with Customer Industry Count and Mean Distance as excluded instruments used in the first stage for Supplier Dummy and Co-dependence. Industry dummies are included for the Fama and French 48 industries. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Ordered-Logit	Instrumental Variables	IV-Ordered Logit	Investment Grade Logit	Downgrade Dummy
Supplier Dummy	-0.953	-0.760	-2.756	-1.580	-0.406	0.303
	(0.000)	(0.000)	(0.059)	(0.027)	(0.057)	(0.024)
Co-Dependence	0.278	0.269	13.218	4.556	1.832	-1.327
	(0.005)	(0.001)	(0.069)	(0.008)	(0.085)	(0.100)
Log(total assets)	1.069	0.878	1.102	0.871	0.138	0.019
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-6.115	-5.079	-6.528	-5.123	-0.784	0.249
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	7.887	6.682	7.256	6.377	0.393	-0.608
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CV(operating income)	-1.934	-1.659	-1.993	-1.677	-0.257	0.137
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated debt	-1.448	-0.953	-1.354	-0.879	–0.255	-0.035
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.023)
Asset Tangibility	1.261	1.267	1.089	1.173	0.161	0.088
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.014)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	12,755	12,755	12,755	12,755	12,755	12,755
R^2	0.6006					
Pseudo R^2		0.1872		0.1799		
F-Statistic	407.75		200.18		191.28	15.02

Table 13: Dependence on Suppliers and Credit Risk

Pooled regressions using OLS and Heckman selection models. The sample consists of rated Compustat firms during the period from 1985 to 2008. Customer Dependence on Suppliers is defined as the purchases from suppliers divided by firm cost of goods sold. Instruments are the number of supplier industries within the firm's state and the average number of companies in supplier industries and are used to obtain the Inverse Mills Ratio in a first stage regression to correct the model for incidental truncation. All independent variables are lagged one year. Industry dummies are included for the Fama and French 48 industries. In linear models, the estimations correct the error structure for clustering at the firm level. P-values are in parentheses.

	Linear		Ordered Logit	
	(1)	(2)	(3)	(4)
Customer Dependence	-2.961	-2.614	-1.681	-1.563
on Suppliers	(0.000)	(0.000)	(0.001)	(0.001)
Inverse Mills Ratio	2.292		1.021	
	(0.056)		(0.224)	
Log(total assets)	1.828	1.167	1.371	1.067
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-8.004	-6.130	-6.819	-6.010
	(0.000)	(0.000)	(0.000)	(0.000)
Operating Income	10.427	8.541	6.670	5.870
	(0.000)	(0.000)	(0.000)	(0.000)
CV(operating income)	-1.498	-1.639	-1.844	-1.896
	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated debt	-1.970	-1.651	-0.688	-0.533
	(0.000)	(0.202)	(0.236)	(0.288)
Asset Tangibility	4.960	3.227	2.141	1.649
	(0.000)	(0.023)	(0.000)	(0.000)
Industry Dummies	Yes	Yes	Yes	Yes
N	465	465	465	604
Pseudo-R^2			0.1981	0.1976
F-statistic	26.91	26.67		

Table 14: Supply-Chain Disruptions

In Panel A, the sample consists of rated Compustat firms during the period from 1985 to 2008 whose industries have at least one firm that experience a declared state of emergency. In Panel B, the sample consists of rated Compustat firms during the period from 1985 to 2008 whose customers' industries have at least one firm that experience a declared state of emergency. Cross-sectional Means, Medians, and Standard Deviations calculated over all events are reported in the Pre-period, i.e., one-year period prior to the events, and in the Post-period, i.e., one-year after the events. Means are compared in the last column. ** denoted significance at the 1% level and * denotes significance at the 5% level. Dependence is the proportion of firm sales to major customers.

Panel A: Industry Shock

The sample consists of rated Compustat firms during the period from 1985 to 2008 whose industries have at least one firm that experience a declared state of emergency.

	Pre			Post			Change
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean
Dependence	0.36	0.29	0.25	0.41	0.37	0.28	0.05**
% of firms with Major Customers	0.20	0.00	0.40	0.25	0	0.43	0.05**
Credit Rating	16.94	17.00	3.71	16.27	16.00	3.60	-0.67**
Bond Price	124.42	69.21	134.03	156.79	67.68	243.35	29.36
Leverage	0.16	0.11	0.17	0.16	0.09	0.17	-0.01*
Total assets	4.73	4.62	2.04	4.91	4.79	2.04	0.18**
Operating Income	0.08	0.12	0.18	0.06	0.11	0.20	-0.03**
CV(Operating Income)	0.61	0.49	0.43	0.62	0.51	0.43	0.01
R&D	0.29	0.24	0.22	0.27	0.20	0.23	-0.02**
Market Capitalization	968.59	94.29	3469.96	1141.26	110.05	3874.36	172.70**
Profit Margin	0.23	0.32	0.85	0.22	0.34	1.01	-0.02
Z-score	2.99	1.28	13.85	3.48	1.11	15.92	0.48*

Panel B: Customer Industry Shock

The sample consists of rated Compustat firms during the period from 1985 to 2008 whose customers' industries have at least one firm that experience a declared state of emergency.

	Pre			Post			Change
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean
Dependence	0.461	0.429	0.264	0.463	0.421	0.277	0.002
Credit Rating	15.594	15.000	3.222	15.470	15.000	3.479	-0.123
Bond Price	235.979	61.209	392.55	198.112	139.476	186.832	-37.867
Leverage	0.138	0.071	0.165	0.143	0.082	0.168	0.005
Total assets	4.848	4.755	1.923	4.866	4.755	2.017	0.019
Operating Income	0.052	0.100	0.193	0.028	0.091	0.221	0.024*
CV(Operating Income)	0.681	0.580	0.429	0.700	0.603	0.448	0.018
R&D	0.254	0.171	0.236	0.260	0.173	0.241	0.005
Market Capitalization	1153.02	131.568	4051.51	987.686	122.33	3572.71	-165.30
Profit Margin	0.198	0.368	1.103	0.202	0.362	1.035	0.004
Z-score	3.814	1.200	16.516	2.077	1.022	11.825	-1.736**

REFERENCES

Ali, A., Klasa, S., and Yeung, E, 2008, "The Limitations of Industry Concentration Measures Constructed with Compustat Data: Implications for Finance Research." Review of Financial Studies, 22, pp. 3839-3871

Allen, J. and G. Phillips, 2002, "Corporate Equity Ownership, Strategic Alliances, and Product Market Relationships." Journal of Finance, 55, pp. 2791-2815

Ammer, J. and F. Packer, 2000, "How Consistent are Credit Ratings? A Geographic and Sectoral Analysis of Default Risk." Working Paper, Board of Governors of the Federal Reserve System, International Finance Discussion Papers Number 686

Ashbaugh-Skaife, H., Collins, D.W., LaFond, R., 2006, "The Effects of Corporate Governance on Firms' Credit Ratings." Journal of Accounting and Economics, 42, pp.203-243

Banerjee S., Dasgupta S., and Kim Y., 2008, "Buyer-supplier relationships and the stakeholder theory of capital structure." Journal of Finance, 63(5), pp 2507-2552

Barclay, M., and C. Smith, 1995b, "The Priority Structure of Corporate Liabilities." Journal of Finance, 50, pp. 899-917.

Bertrand, K., 1986, "Crafting Win-Win Situations in Buyer-Supplier Relationships." Business Marketing, 71, pp. 42-50

Brown, M., Falk, A., Fehr, E., 2004, "Relational Contracts and the Nature of Market Interactions." Econometrica, 72, pp. 747-780

Bull, Clive. 1987, "The Existence of Self-Enforcing Wage Contracts." Quarterly Journal of Economics, 102, pp.147–59.

Cowley, P.R., 1988, "Market Structure and Business Performance: An Evaluation of Buyer/Seller Power in the PIMS database." Strategic Management Journal, 9, pp. 271-278

Craighead, C.W., Blackhusrt J., Rungtusanatham, M.J., 2007, "The Severeity of Supply Chain Disruptions Design Characteristics and Mitigation Capabilities." Decision Sciences, 38, 1, pp. 131-156

Das, S.R., Duffie, D., Kapadia, N., Saita, L., 2012, "Common Failings: How Corporate Defaults are Correlated." Journal of Finance, Forthcoming.

Davis, M., Lo, V., 2001, Modeling default correlation in bond portfolios. In: Alexander, C. (Ed.), Applications. Financial Times. In: Mastering Risk, vol. 2. Prentice Hall, pp. 141–151.

Faulkender, M., and M. Petersen, 2006, "Does the Source of Capital Affect Capital Structure," Review of Financial Studies, 19, pp. 45-79.

Fink, R.C., Edelman, L.F., Hatten, K.J., James, W.L., 2006, "Transaction cost economics, resource dependence theory, and customer supplier relationships." Industrial and Corporate Change 15, pp. 497-529.

Giesecke, Kay and Stefan Weber, 2004, "Cyclical correlations, credit contagion, and portfolio losses," Journal of Banking & Finance 28, pp. 3009-3036.

Gompers, Paul A., Joy L. Ishii, and Andrew Metrick, 2003,"Corporate Governance and Equity Prices." The Quarterly Journal of Economics 118 (1), pp. 1007-155.

Graham, J., M. Lemmon, and J. Schalheim, 1998, "Debt, Leases, Taxes, and the Endogeneity of Corporate Tax Status." Journal of Finance, 53, pp. 131-162.

Hendricks, K. and Singhal, V. 2003, "The Effect of Supply Chain Glitches on Shareholder Wealth." Journal of Operations Management, 21, pp. 501- 522.

Hertzel, M., Li, Z., Officer, M., and Rodgers, K., 2008. "Inter-firm linkages and the wealth effects of financial distress along the supply chain: rivals, customers, and suppliers," Journal of Financial Economics, 87, pp. 374-387.

Hui, K., Klasa, S., Yeung, E., 2011, "Corporate Suppliers and Customers and Accounting Conservatism." Journal of Accounting and Economics, Forthcoming

Horrigan, J., 1966, "The determination of long-term credit standing with financial ratios," Journal of Accounting Research, 4, pp. 44–62.

Hovakimian, A., A. Kayhan, and S. Titman, 2009, "Credit Rating Targets." Working Paper

Hovakimian, A., T. Opler and S. Titman, 2001, "The Debt-Equity Choice." Journal of Financial and Quantitative Analysis, 36, pp. 1-24.

Jackson, B. 1985, Winning and Keeping Industrial Customers: The Dynamics of Customer Relationships. Lexington, MA: Lexington Books

Jarrow, R.A., Yu, F., 2001, "Counterparty risk and the pricing of defaultable securities." Journal of Finance, 56 (5), pp. 555–576.

Jorion, P. 2005. Financial Risk Manager Handbook. John Wiley & Sons, Inc. New Jersey

Jorion, P. and G. Zhang, 2009, "Credit Contagion from Counterparty Risk," The Journal of Finance, 64, pp. 2053-2087.

Joskow, P., 1988, "Asset Specificity and the Structure of Vertical Relationship: Empirical Tests of Transaction Cost Analysis," Journal of Law, Economics, and Organization 4, pp. 121-139.

Kale and Sharur, 2007, "Corporate Capital Structure and the Characteristics of Suppliers and Customers," Journal of Financial Economics, 83, pp. 321-365

Kalwani M., and N. Narayandas, 1995, "Long-term manufacturer-supplier relationships: Do they pay off for supplier firms?" Journal of Marketing 59, pp. 1-16.

Kaplan, R and G Urwitz , 1979, "Statistical models of bond ratings: A methodological inquiry." Journal of Business, 52, pp. 231–261.

Kisgen, D., 2006, "Credit Ratings and Capital Structure." The Journal of Finance, 60, pp. 1035-1071

Klein, P., 2005, "The Make-or-Buy Decision: Lessons from Empirical Studies," in Ménard, C. and M. Shirley, eds, Handbook of New Institutional Economics, Dordrecht: Springer

Klein, B., and Leffler, K. 1981, "The role of market forces in assuring contractual performance." Journal of Political Economy, 89, pp. 615-641

Klock, M.S., Mansi, S.A., Maxwell, W.F., 2005, "Does Corporate Governance Matter to Bondholders?" Journal of Financial and Quantitative Analysis, 40, pp. 693-715

Knight, R. and Pretty, D., 1996, "The Impact of Catastrophes on Shareholder Value." The Oxford Executive Research Briefings, Templeton College, University of Oxford, Oxford, England

Lang, L., Stulz, R., 1992, "Contagion and competitive intra-industry effects of bankruptcy announcements." Journal of Financial Economics, 32, pp. 45–60.

Macaulay, S., 1963, "Non-Contractual Relations in Business: a Preliminary Study." American Sociological Review, 28, pp. 55-67

Matsumura, E.L., and J.D. Schloetzer, 2009, "Strong Buyers and Inter-Organizational Cost Management." Working Paper

Mitroff, I. and Alpasan, M., 2003, "Preparing for Evil," Harvard Business Review, pp. 109-115.

Nelson, F., and L. Olsen, 1978, "Specification and Estimation of a Simultaneous Equation Model with Limited Dependent Variables." International Economic Review, 19, pp. 695-705

Nickell, P., Perraudin, W., and Varatto, S., 2000, "Stability of Rating Transitions." Journal of Banking and Finance, 24, pp. 203-227

Noordewier, T.G., G. John and J.R. Nevin, 1990, "Performance outcomes of purchasing arrangements in industrial buyer-vendor relationships." Journal of Marketing, October, pp. 80-93.

Patatoukas, 2010, "Customer-base Concentrations: Implications for Firm Performance and Capital Markets." Working Paper

Sheth, J.N. and A. Sharma, 1997, "Supplier Relationships: Emerging Issues and Challenges." Industrial Marketing Management, 26, pp. 91-100.

Smith, R.J., and R.W. Blundell, 1986, "An Exogeneity Test for the Simultaneous Equation Tobit model with an Application to Labor Supply." Econometrica, 54, pp. 679-685

Standard and Poor's, 2001, Corporate Ratings Criteria (McGraw-Hill, New York).

Tang C.S., 2006, "Robust strategies for mitigating supply chain distruptions." International Journal of Logistics: Research Applications, 9, 1, pp. 33-45

Titman S., 1984, "The effect of capital structure on a Firm's liquidation decision, " Journal of Financial Economics, 13, pp. 137-151.

Titman S. and R. Wessels, 1988, "The determinants of Capital Structure Choice," Journal of Finance, 43, pp. 1-19.

Tonkin, L., 1989, "Hanging the rules in the supplier-buyer game," Manufacturing Systems, October, pp. 28-32

Standard and Poor's, 2002, ''Corporate Ratings Criteria.''

Wagner, S.M., and Bode, C., 2006, "An empirical investigation into supply-chain vulnerability." Journal of purchasing and supply management, 12, pp. 301-312

Williamson, O.E., 1979, "Transaction-Cost Economics: The Governance of Contractual Relations." Journal of law and economics, 22, pp. 233-261

Williamson, O.E., 1987, "Transaction-Cost Economics: The Comparative Contracting Perspective." Journal of Economic Behavior and Organization, 8, pp. 617-625

Woolridge, J. "Sample Selection, Attrition, and Stratified Sampling." Econometrics Analysis of Cross Section and Panel Data. Massachusetts Institute of Technology. 2002