

Different ways of managing risk as reported in 10-Ks:

## A supervised learning approach

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### Abstract

We use supervised learning on annual reports of publicly listed U.S. firms (10-Ks) to build textual measures of risk management via derivatives, insurance, diversification, long-run contracts, and credit lines. Validation exercises favor these supervised learning-based measures over those based on word lists. Panel regressions (1996–2015) indicate that firms using one form of risk management are more likely to also use other forms. In contrast, intensive use of one risk management technique associates with less intensive use of other methods. Findings are consistent with a model featuring fixed costs of organizational capacity for managing risks and increasing marginal costs of hedging.

## 1 INTRODUCTION

Risk management is the key to understanding the survival and growth of firms under adverse circumstances and a rich arsenal of risk management tools and techniques are available. Broadly, we can distinguish three different types of tools for managing risk (see, e.g., Meulbroek [2002] or Friberg [2015]): (i) financial (e.g., derivatives or insurance), (ii) operational (e.g., diversification) or (iii) ensuring access to liquidity (e.g., precautionary cash holding or credit lines). This paper contributes to the understanding on how firms combine these different ways of managing risk.

A challenge that researchers face is that many aspects of risk management are difficult to observe; for instance, use of insurance is not available in any standard data sets. To circumvent this problem, we develop measures of risk management based on textual analysis of annual reports (10-Ks) that we combine with financial data from Compustat. Several researchers have previously applied textual analysis to 10-Ks (see, e.g., Loughran & McDonald [2016] for a survey) but in terms of measurement this paper contributes to the existing literature in two ways: (i) it broadens the scope of textual analysis of risk

management to include, for instance, use of insurance, and (ii) rather than relying on prespecified word lists, a supervised learning algorithm is applied to identify sentences that discuss ways of managing risk. First, we manually read and annotate a randomly selected set of 10-Ks and train the algorithm on these data. We then use our algorithm to read and classify all text in Item 1 and Item 1A of U.S. annual reports filed with the Securities and Exchange Commission (SEC) between fiscal years 1996 and 2015. We validate our text-based measures using outside measures of risk management that are available for subsets of our sample (e.g., an indicator of derivatives use based on Compustat data and credit line use from Sufi, 2009). When we examine externally available measures of derivatives use (from Compustat and from Almeida, Campello, Cunha, & Weisbach, 2017) we find that the supervised learning algorithm is more accurate than a word list in measuring risk management, a contribution that we believe will be valuable for future work.

Our textual analysis delivers measures on five risk management practices that vary by firm and fiscal year: derivatives, insurance, credit lines, long-run contracts, and diversification. A large body of literature examines different ways of managing risk, but it typically focuses on only one way of managing risk in a given paper.<sup>1</sup> In contrast, our key focus is on how different ways of managing risk *interact*. Are firms that use one way of managing risk also using other ways of managing risk? In the empirical literature on risk management, this question has largely been framed in terms of whether different ways of managing risks are “complements” or “substitutes.”<sup>2</sup>

As we discuss later, some risks can almost exclusively be handled by one risk management tool, while several other risks can at least partly be handled with multiple tools. For instance, an exporter aiming to limit exchange rate exposure can use foreign currency derivative contracts to hedge, but can also hedge operationally by producing locally in for-

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<sup>1</sup>The literature is especially rich when it comes to precautionary cash holding (Bates, Kahle, & Stulz, 2009; Almeida, Campello, Cunha, & Weisbach, 2014) and financial hedging (Geczy, Minton, & Schrand, 1997; Bodnar, Hayt, & Marston, 1998).

<sup>2</sup>There is also a set of theoretical articles that examines interactions: see, for example, Chod, Rudi, and Van Mieghem (2010) or Bolton, Chen, and Wang (2011). An important takeaway from the theoretical literature is that the value of one form of risk management potentially depends on the use of other forms of risk management.

eign markets. Such logic would suggest that financial hedging and operational hedging are alternatives or substitutes. However, one can also envision circumstances when financial hedging and operational hedging are observed simultaneously and are complements—for instance if different tools are suited for different horizons. The literature that examines the combined use of different ways of managing risk has been especially focused on the relation between the use of currency derivatives and international operations, where the latter is taken as a measure of operational hedging. Painting with a broad brush, the results in Allayannis, Ihrig, and Weston (2001), Kim, Mathur, and Nam (2006), and Bartram, Brown, and Minton (2010) all suggest complementary effects of financial hedging and operational hedging. An important strand of the literature thus interprets the results as supporting the complements interpretation.

On the other hand, substantial research supports the substitutes interpretation. In particular, there is robust evidence that cash holding is negatively related to diversification, thus indicating that operational hedging (i.e., diversified operations) lowers the need for precautionary cash holding (Duchin, 2010; Bakke & Gu, 2017). Other dimensions of the interaction between different ways of managing risk are less explored, but there are several additional investigations that also support the substitutes interpretation.<sup>3</sup>

At first glance, the previous literature thus seems divided on whether different ways of managing risks are substitutes or complements. To understand the varying results, we note that previous literature has frequently been hampered by having only indicator variables of risk management (e.g., a dummy variable to capture if the firm uses derivatives). We show that the results differ substantially depending on whether indicator variables or continuous measures of risk management are used. All the risk management tools we investigate are positively correlated when we use indicator variables to capture different ways of managing risk.<sup>4</sup> For instance, a firm that uses insurance to deal with risks is also

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<sup>3</sup>Hankins (2011) shows how increased operational hedging as a result of mergers implied less financial hedging in a sample of bank holding companies. Almeida, Hankins, and Williams (2017) show that purchase obligations, a form of supplier contracts, serve as a substitute for derivatives. Hoberg and Moon (2017) find that firms use derivatives to hedge in markets where such derivatives are liquid but otherwise tend to favor a form of operational hedging—purchasing inputs from the same markets they sell outputs to.

<sup>4</sup>The exception is cash holding, which is not well captured by an indicator variable.

more likely to use derivatives. If we instead capture the extent of risk management by continuous measures, a negative relation dominates. For instance, more diversified firms use less derivatives, insurance, credit lines and long-run contracts and hold less cash. An exception to this negative pattern is that the use of credit lines, insurance, and derivatives tends to be positively correlated.

The mostly positive relation between indicator variables of different ways of managing risk at the same time as the overall relations are mostly negative may initially seem puzzling. An important contribution of this paper is not only to consider a wider set of ways managing risk, and how they are combined, but also to provide a model-based interpretation of results that appear contradictory at first. We show how fixed costs of building capacity to use a specific tool to manage risk, combined with increasing marginal costs to use a certain way to cover a particular risk, can generate the observed pattern. Fixed costs of building capacity may, for instance, reflect the costs of creating management processes and hiring the critical level of staff needed to use derivatives or to commit to long-term contracts with suppliers. Increasing marginal costs of using a particular form of risk management capture that—for example, some exposures are likely to be relatively cheap to cover with derivatives but the more exposures that a firm covers with derivatives, the more complex instruments and analysis are needed.

Consider a car manufacturer, for instance. Covering some exposures (such as short-term exposure to the euro) with derivatives is likely to be cheap, at the same time as covering other exposures with long-run supplier contracts is also likely to be cheap. Conditional on having taken the fixed costs, it is cheaper for such a firm to use both derivatives and long-run contracts to manage exposures rather than to try to cover all risks with only derivatives or only with long-run contracts. Fixed costs of capacity and increasing marginal costs for using a particular tool to manage risk can thus explain why larger firms are more likely to engage in risk management and why several ways of risk management tend to be used in tandem. On the other hand, if one form of managing risks becomes more expensive—for instance, if long-term contracts become costlier because of changing legal rules—then such a firm would naturally tend to rely less on long-term

contracts and more on derivatives. That is, the intensity of use of different ways of managing risk would tend to be negatively related.

One simple intuition for our findings notes that it is not puzzling if a consumer who enjoys fruit buys both apples and pears (positive indicator variables for both) but buys more apples and fewer pears if the price of pears increases (goods are substitutes). This is also the reason why we diverge from much of the previous literature and avoid the commonly used terms *substitutes* and *complements* to interpret our results. In economic theory, these terms have a precise definition tied to the sign of cross-price effects, whereas the use of these terms in the risk management literature varies to some extent between articles and is not always clearly defined.

The next section presents the data and the text-based measures of risk management.<sup>5</sup> Section 3 provides validation exercises for the text-based measures of risk management. Section 4 presents the main empirical analysis and interprets the findings. Section 5 concludes.

## 2 DATA

### 2.1 Building measures of risk management from annual reports

We create measures of risk management by textual analysis of Item 1 and Item 1A in the annual reports (form 10-K) of U.S. firms.<sup>6</sup> The regulations stipulate that Item 1 describes the general development of the business of the filing firm: for instance, principal products, dependence on a limited set of customers, and competitive conditions are topics that must be discussed. Item 1A requires a concise discussion of the most significant factors that make the offering risky. Many firms discuss risk factors from the start of the sample period, but it is required only from 2005 onward. For brevity, we simply refer to these sections as Item 1 such that if not stated otherwise, Item 1 is considered to include Item

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<sup>5</sup>An Online Appendix with details on how the textual data were assembled as well as many robustness exercises is available in the supporting materials section online.

<sup>6</sup>See <https://www.sec.gov/about/forms/form10-k.pdf>. Information that must be included in these sections of 10-K is stipulated in Items 101 and 503(c) of Regulation S-K under the U.S. Securities Act of 1933.

1A.

We download all 10-Ks from the SEC EDGAR servers for fiscal years 1995–2015 and identify Item 1. After excluding financial firms, this gives us a final data set that includes 75,627 annual reports that each, on average, has 343 sentences in Item 1. To analyze the extent to which these texts discuss risk management, we rely on two methods. The first is a supervised learning algorithm that relies on manual reading and classification, and the second relies on a word count that uses prespecified dictionaries.

### 2.1.1 A supervised learning algorithm

We first develop a sentence classification algorithm that is trained on a randomly selected, manually annotated set of Item 1's. The training data set comprised a random draw of 10% of Item 1's for calendar years 2006 and 1998. Through the lens of three broad classes of risk management practices (financial hedging, operational hedging, and access to liquidity), we manually read and tag sentences dealing with risk management in the training data. We now provide a brief summary of the classification scheme as well as the training of the classifier. The Online Appendix presents detailed accounts of all aspects of the supervised learning algorithm.

First, we use the term *financial hedging* to denote contracts with financial counterparties that create an offsetting stream of revenue in the case that certain states of the world materialize. We consider two such forms of risk management: (i) derivatives (we make a broad interpretation and include options, futures, forwards, swaps, and other state-contingent contracts with financial partners) and (ii) insurance.<sup>7</sup> An example of a derivatives sentence is, “The Company has a fuel hedging program in which it enters into jet fuel, heating oil and crude oil hedging contracts to dampen the impact of the volatility of jet fuel prices.” An example of a sentence capturing the use of insurance is, “We carry insurance for public liability, passenger liability, property damage and all-risk coverage for damage to our aircraft.” Both of these examples are from the 10-K of AMR

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<sup>7</sup>The use of the former are relatively well documented in previous research (see, e.g., Geczy, Minton, & Schrand, 1997; Guay & Kothari, 2003) whereas the empirical literature on insurance is limited and mainly comprises case studies (e.g., reinsurance of catastrophe risk in Froot [2001] or property insurance in Aunon-Nerin & Ehling [2008]).

(2006), the parent of American Airlines.

Second, the firm may act to modify the relation between operating profits and the state of the world. We refer to such measures as *operational hedging*, and in the analysis we use sentences that encompass five different forms of operational hedging.<sup>8</sup> We combine three of these (broad customer base, broad supplier base, and other diversification) under the heading “diversification.”<sup>9</sup> To obtain the flavor of the type of sentences tagged, we exemplify a broad supplier base with Chiquita (2006): “The geographic diversity of our suppliers helps us to lessen the effects of any event that could cause production declines in a single region.” A broad customer base can be exemplified with Ikon (2006), “Our customer base is broad and diverse, numbering approximately 500,000 organizations, including global and national companies, representing over 100 of the Fortune 500 companies, major regional companies, mid-size businesses, professional services firms, and state, local and federal government agencies.” Other diversification is illustrated with a sentence from Alico (2006): “The assets of Plant World were purchased for the purpose of diversifying Alico’s agricultural operations.”

Two other classes capture long-run contracts with suppliers and customers that contain a risk management dimension: one tags sentences capturing long-run contracts per se, and the other tags renegotiation clauses in long-run contracts. An example of a contract relating to long-run contracts is from Chiquita (2006): “For lettuce, we often enter into contracts with these growers to help mitigate supply risk and mitigate exposure to cost risks.” Renegotiation clauses are illustrated by Coca-Cola (2006): “This baseline price may be adjusted periodically by the Company, up to a maximum indexed ceiling price, and is adjusted quarterly based upon changes in certain sugar or sweetener prices, as applicable.”

Both of the above ways of managing risk rely on ex ante measures that modify outcomes in different states of the world. In a third way to manage risk, the firm may undertake measures that strive to provide it with *access to liquidity* should adverse states

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<sup>8</sup>Our initial reading included four additional classes: “flexibility,” “other operational hedging,” “outsourcing,” and “risk transfer.” See the Online Appendix for further details.

<sup>9</sup>Diversification as a way of managing risk has deep roots. See, for example, Ho , Zheng, Yildiz, and Talluri (2015) for an overview or Chod, Trichakis, and Tsoukalas (2019) for a recent contribution.

materialize (or investment opportunities). A strong balance sheet can broadly provide access to liquidity. We follow previous literature and focus on two ways of providing liquidity: precautionary cash holding (Bates, Kahle, & Stulz, 2009; Almeida, Campello, Cunha, & Weisbach, 2014) and lines of credit (Sufi, 2009; Campello, Giambona, Graham, & Harvey, 2011). To capture this form of risk management we build a text-based measure of credit lines and rely on Compustat data to capture cash holdings.

The manually identified text serves as a training ground for the Stanford Classifier<sup>10</sup> from the Stanford Natural Language Processing Group in identifying sentences related to risk management in Item 1. It is a maximum entropy classifier of a type commonly used in machine learning.

Having trained the algorithm, we use it to classify all the text in Item 1 of all annual reports between fiscal years 1996 and 2015 and assign sentences to risk management categories. This procedure generates a “sentence-level” data set, which contains all the identified risk management sentences. We also store the length of the identified Item 1. From these sentence counts, we create the following text-based measures of risk management:  $\text{Derivatives}_{it}$  is defined as the number of derivative sentences for firm  $i$  in fiscal year  $t$  divided by the total number of sentences in Item 1 for firm  $i$  in fiscal year  $t$ .  $\text{Insurance}_{it}$ ,  $\text{Credit lines}_{it}$ ,  $\text{Long-run contracts}_{it}$  and  $\text{Diversification}_{it}$  are calculated in the same way. All five text-based variables are thus continuous measures and we multiply the sentence shares by 100 such that they are expressed in percent. We also create analogous indicator variables (0/1) that take the value one when we identify at least a single sentence that discusses the particular form of risk management for firm  $i$  in fiscal year  $t$  and denote it as  $> 0$ . Thus, for instance  $\text{Derivatives}_{it} > 0$  is 1 for a user of derivatives.

Table 1 provides summary statistics on the measures of risk management.<sup>11</sup> Note that derivatives, insurance, and credit lines are zero for many observations. In contrast, long-run contracts and diversification are discussed by nearly all firms, but there is substantial

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<sup>10</sup><https://nlp.stanford.edu/software/classifier.html>

<sup>11</sup>There are 75,626 observations on the text-based measures, but the Compustat data are not available for all these firms and years. Tables 1 and 2 therefore give summary statistics for the 48,560 observations that form the core regression sample used in Tables 5–7. In some of the later validation tests, the number of observations is lower yet, since the external measures of risk management that we compare our text-based measures against are available for only a subset of observations.

variation. These findings highlight that if we only focus on derivatives in an analysis of risk management, we are missing large parts of the picture. The summary statistics also indicate that the 0/1 margin of different ways of managing risk may play an important role.

[Table 1 about here]

### **2.1.2 An alternative approach to textual analysis: Dictionaries**

The supervised learning methods that we use are labor intensive because they require manual annotation of substantial bodies of text. So far, textual analysis of 10-Ks has instead largely relied on a dictionary approach where a list of words (or terms) is created and the occurrence of those words are counted in each 10-K. We complement our supervised learning methods with such a dictionary approach. If the two approaches yield similar results, this would be a valuable input for future research that could then rely on a simpler method with little loss of precision. In contrast, if the results differ, the expected gain in precision will have to be weighted against an increased cost of data collection.

Using the same sample as above (Item 1 from 10-Ks), we check for words and phrases from a set of dictionaries. The dictionaries are detailed in the Online Appendix. For derivatives, we follow the dictionary from Disatnik, Duchin, and Schmidt (2014), and for insurance, we create a new set of words related to insurance. For aspects of operational hedging, we create a set of words related to operational hedging. In addition, we build a set of words that aim to capture flexibility, the latter inspired by the literature on real options (e.g., Chevalier-Roignant & Trigioris, 2011). For access to liquidity, we use a word list that contains a set of words and terms capturing precautionary motives for access to liquidity as well as a set of terms related to credit lines that follow Sufi (2009). Finally, we also used a word list to capture if firms engage in enterprise risk management (ERM, Bromiley, McShane, Nair, & Rustambekov, 2015).

[Table 2 about here]

Table 2 presents summary statistics on these word counts (expressed as shares of the total number of words in the respective Item 1). In all these cases, there is substantial variation; only in the case of derivatives is the mean greater than the standard deviation. As observed in the right-most column, the share of ERM-related words is minuscule; also at the 95th percentile, the share is zero.<sup>12</sup>

The bottom row presents the correlation with the most closely related measure based on supervised learning that we use in the main analysis. The correlations are positive. For insurance the correlation is relatively high at 0.64 but slightly lower than 0.4 for derivatives and credit lines. We present a comparative discussion of word counts versus supervised learning algorithms in Section 3.

## 2.2 Other data

We complement the text-based data on risk management with financial information on these firms from Compustat and match it by fiscal year.<sup>13</sup> We thus calculate cash holding, cash flows, and leverage, all scaled by total assets.<sup>14</sup> We also include market-to-book in regressions below.<sup>15</sup>

In addition, we use Compustat segment files to generate information on the number of four-digit Standard Industrial Classification (SIC) segments in which a firm is active and information on the number of geographical segments. This is available for fiscal years 1997–2013 inclusive.

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<sup>12</sup>The share of ERM-related words has been increasing over time but even in 2015 there were only about 250 ERM-related words in the sample (out of a total 52 million words in the sample during that year). Thus, although a substantial interest in a broader view of risk management is apparent, it is clear that this is not reflected in how firms discuss their situation in 10-Ks.

<sup>13</sup>We match via the unique firm identifier GVKEY and fiscal year (FYEAR) using the WRDS Linking Table. All Compustat data are winsorized at the 1st and 99th percentiles.

<sup>14</sup>Specifically, we calculate the following (Compustat acronyms in capital letters): Cash holdings are measured by cash and short-term investments and scaled by total assets so that cash holding is given by  $100 \times (\text{CHE}/\text{AT})$ . We calculate cash flow as operating income after depreciation (OIBDP) minus total interest and related expenses (XINT), total income taxes (TXT) and dividends (DVC) and scale by total assets such that cash flow is given by  $\times(\text{OIBDP}-\text{XINT}-\text{TXT}-\text{DVC})/\text{AT}$ . Leverage is calculated as long-term debt (DLTT) plus debt in current liabilities (DLC) and scaled by assets  $\times(\text{DLTT}+\text{DLC})/\text{AT}$ .

<sup>15</sup>This is calculated as total assets plus the closing share price (PRCC\_F) times the number of shares outstanding minus common equity (CEQ) as  $\times(\text{AT}+\text{PRCC\_F} \times \text{CSHO}-\text{CEQ})/\text{AT}$ .

### 3 VALIDATION EXERCISES

An assumption in this paper is that the share of sentences that are identified as relating to a particular form of risk management is informative about the relative importance of managing risk in that way. A foundation for the expectation of a positive correlation between sentence share and intensity of use stems from the evidence that textual risk disclosures in 10-Ks are informative to investors (Kravet & Muslu, 2013; Campbell, Chen, Dhaliwal, Lu, & Steele, 2014; Loughran & McDonald, 2016). Furthermore, a useful comparison can be made between some of our text-based measures and alternative measures. In the following, we explore if such comparisons support the notion that the text-based measures are informative of risk management practices. Additional results are reported in the Online Appendix.

First, Compustat contains information about unrealized gains from financial hedging (Compustat variable AOCIDERGL, available from 2001 onward) and gains or losses on ineffective hedges (Compustat variable HEDGEGL, available from 2005 onward). Nonzero values on either of these can be used to infer that the firm uses derivatives and thereby provide the opportunity to compare with the results from our text-based measures. In Table 3, we cross-tabulate this Compustat-based derivative indicator variable against an indicator variable based on our textual analysis from 2005 onward. For instance, a firm-year observation that is classified as a derivatives non-user based on our textual analysis and as a non-user based on the Compustat derivative indicator, will be recorded in the upper left-hand corner. A couple of issues are noteworthy. First, the two measures line up relatively well, with 51% characterized as derivative non-users under both definitions and 16% as derivative users under both definitions. Second, the share of users of derivatives is higher in the text-based definition (38%) than in the Compustat definition (27%). This is expected as a firm may use derivatives but may not have any unrealized gains or ineffective hedges, as defined by AOCIDERGL or HEDGEGL. This also means that 22% of observations in the lower left-hand corner are not an indictment of the textual analysis. Somewhat more worrying is that 11% of observations use derivatives according to Compustat but not according to our algorithm.

[Table 3 about here]

We proceed to examine the intensity of derivatives use and compare it with the dichotomous Compustat-based variable. The top row of Panel A in Table 4 first provides the mean (standard errors in parentheses) of our main text-based measure of using derivatives for all observations; next, in Column 2 for observations that are not defined as hedgers under the Compustat-based definition and in Column 3 for observations that are defined as hedgers following the Compustat-based definition. The share of sentences that are defined as pertaining to using derivatives is higher for firms that are defined as hedgers following the Compustat-based definition and the difference is both statistically and economically significant, thus confirming the impression from the cross-tabulation in Table 3.

The second row of Panel A in Table 4 makes the same comparison for our dictionary-based measure of derivatives, and as can be observed, the relation with the Compustat measure is much weaker. The t-statistic is sufficiently high that equality can be rejected at the 1% level; however, economically, the difference is trivial. Although the Compustat measure of using derivatives should not necessarily be seen as “correct,” the first two lines nevertheless strongly support our supervised learning over a dictionary approach. We also trained the algorithm to explicitly predict the non-use of risk management. This proved less successful than predicting use and we did not use these data in the present paper. However, it provides yet another opportunity to check the algorithm. The third row, therefore, gives the share of sentences explicitly discussing the non-use of derivatives and, as observed, the share is much lower than the share of sentences discussing the use of derivatives. The share of non-use sentences is also lower among firms that are designated as users of derivatives based on Compustat, even though the difference is only marginally statistically significant at the 10% level.<sup>16</sup>

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<sup>16</sup>Note that a nonzero share here may at first appear as a predictive failure, which it need not be. For instance, a firm may use one sentence to say, “We do not use weather derivatives to hedge exposure,” in the same document as it states that “We use forward contracts to hedge euro exposure.” A single positive sentence is sufficient to make it a derivatives user, but one negative sentence is not enough to make it a non-user.

[Table 4 about here]

Panel B uses another potential comparison with Compustat data and compares our text-based measure of diversification across firms that operate in only one four-digit SIC industry (following Compustat segment files) to those that operate in several industries. As expected, the share of diversification sentences is higher in the latter group, and the difference is statistically significant at the 1% level.

Panel C uses of a list of 42 six-digit North American Industry Classification System (NAICS) industries with traded futures from Almeida, Hankins, and Williams (2017, Appendix B). As expected, when using our text-based measure, we observe a marked difference between the share of derivative sentences among firms in industries with traded futures and those without, and the average share is about five times higher in the former group. Instead, if we consider word counts, we see the same qualitative pattern, but it is much less pronounced.

Panel D splits the sample by an indicator variable from Sufi (2009), who used a combination of dictionary-based textual analysis and manual checks to create an indicator variable for firm–fiscal year observations that had access to a credit line between 1996 and 2003. Again, we see that the share of credit line words is significantly higher for firms that Sufi (2009) classified as having access to credit lines.

Regulations also require that the 10-Ks provide information about market risks and the use of derivatives to manage e.g. commodity and currency risk.<sup>17</sup> The related information is to be found in Item 7A, but an initial manual reading indicated that the information is often cross-referenced to other sections and included in tables which make it harder to apply automated textual analysis. Panel E relies on a manual reading of a stratified random sample of 100 10-Ks to identify firms that use currency or commodity derivatives. Our supervised learning-based measure of derivatives use is significantly higher for firms for which a manual reading of the information (referenced to) in Item 7A indicates that they use commodity or currency derivatives (see the Online Appendix for further discussion).

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<sup>17</sup>This is stipulated in Item 305 of Regulation S-K.

We draw two conclusions from the analysis in this section. First, text-based analysis of Item 1 in 10-Ks provides information on firms' risk management practices. As such, it echoes findings from literature that examines the impact of 10-K text on investor perceptions and actions (e.g., Kravet & Muslu, 2013). We expect the information to be noisy, but it provides a useful complement to other noisy measures of risk management that are potentially available, such as evidence from questionnaires with low response rates. Second, at least in the case of risk management, it appears that supervised learning methods provide more precise results than a dictionary approach.

## 4 RELATION BETWEEN DIFFERENT WAYS OF MANAGING RISK

### 4.1 Empirical specification

We rely on regression analysis to examine the various ways in which firms manage risk. The regressions follow the general format of

$$Y_{it} = \alpha_i + \gamma_t + \beta X_{it-1} + \epsilon_{it}. \quad (1)$$

The dependent variable  $Y_{it}$  is either cash holding or one of the text-based measures of risk management ( $\text{derivatives}_{it}$ ,  $\text{insurance}_{it}$ ,  $\text{credit lines}_{it}$ ,  $\text{long-run contracts}_{it}$  or  $\text{diversification}_{it}$ ). We consider both regressions in levels, and regressions where risk management is captured by indicator variables that take the value one if this form of risk management is discussed, and zero otherwise.

Typically, we include firm fixed effects  $\alpha_i$ , which imply that identification comes from within-firm changes across fiscal years in how much the respective firm discusses a particular form of risk management. We use fiscal year fixed effects  $\gamma_t$  to capture overall developments in how firms discuss risk management. We also include a set of financial variables that are common control variables in corporate finance: cash flows, leverage,

market-to-book, and the natural logarithm of total assets. To limit endogeneity concerns, explanatory variables are lagged one fiscal year.

A potential concern is the likely measurement error in the text-based variables. For instance, although it seems imminently plausible that a firm that assigns more importance to insurance in its management of risk spends a larger share of Item 1 discussing insurance, it is also clear that we only rarely expect a one-to-one relationship between the amounts covered by insurance contracts and the share of sentences discussing insurance.<sup>18</sup> To the extent that measurement error impacts the dependent variable, ordinary least squares (OLS) will remain consistent, but standard errors on coefficients will tend to increase. To the extent that measurement errors affect the explanatory variables, it is likely that there will be some attenuation bias—that is, coefficients will be biased toward zero. As our primary interest is the sign of relations (rather than magnitudes per se), the prime effect of measurement error is, if anything, to make it too easy to reject a hypothesis (by potentially biasing coefficients toward zero and inflating standard errors). To consider the potential correlation of the error term within firms, we cluster standard errors at the firm level.

## 4.2 Analysis with continuous measures of risk management

Table 5 presents the results of a regression analysis of the interrelations between the different continuous measures of risk management that we consider.

[Table 5 about here]

Column 1 indicates that firms hold less cash when they use more derivatives, credit lines, or are more diversified. The literature on cash holding is particularly rich, and the results here are consistent with previous findings (see, e.g., Bates, Kahle, & Stulz, 2009; Duchin, 2010). The other regressions are more novel, and rather than commenting on every individual coefficient, let us consider the overall picture that they paint with regards

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<sup>18</sup>Presuming that we want to consider the insurance variable as capturing the insured amounts. Clearly, the set of risks that are covered, the extent of deductibles, and other variables will potentially affect the extent to which insurance is discussed.

to the coefficients on risk management. Out of a total 30 coefficients, 14 are negative and statistically significant at the 5% level or greater. An additional two coefficients are negative and statistically significant at the 10% level or greater. Only four coefficients are positive and statistically significant. This pattern indicates that by and large, different means of managing risk are alternatives; if a firm uses one form of risk management more, it tends to use less of the other forms.

The four positive and statistically significant coefficients indicate positive relations between credit lines on the one hand and derivatives and insurance on the other hand. We provide an extended discussion of the documented patterns below, but for now, note that the positive relations involve risk management instruments that are developed in association with the financial industry.

Any causal interpretation of the patterns that we document should be done with care. Our preferred interpretation is that our tables report partial correlations, after potentially confounding factors have been controlled for via the inclusion of firm fixed effects, fiscal year fixed effects, and some key accounting variables. Overall, the economic significance of the estimated coefficients is nontrivial. Using results in Column 2 to exemplify the economic significance, we find that a one standard deviation increase in the share of diversification sentences is associated with a decrease in the share of derivatives sentences by 13.2% and a one standard deviation increase in the share of long-run contract sentences with a decrease in derivatives sentences by 6.6%. A one standard deviation increase in the share of credit line sentences is associated with an increase in the share of derivative sentences by 14.5%.

One puzzling finding in the prior literature is that large firms are more likely to use financial hedges (see, e.g., Geczy, Minton, & Schrand [1997] for an early reference). This is surprising because factors leading to a value of risk management explored by theory, such as nondiversified ownership and credit constraints, are typically deemed to be more important for smaller firms.<sup>19</sup> A potential solution to the conundrum may be that smaller

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<sup>19</sup>The Fisher separation theorem implies that a firm's goal should be to maximize its discounted net present value, irrespective of the owners' risk- or time-preferences (see, e.g., Stein, 2003). Even though it is an important benchmark result note that risk aversion creates a value of risk management because the expected value of a concave function is decreasing in the variance of shocks (and risk aversion is

firms manage risk using other tools instead. Using  $\ln(\text{Assets})$  as a proxy for size we see no such pattern in Table 5.

Note, however, that with firm fixed effects, the coefficient on size is identified only from year-to-year variation within firms. To examine the relation between size and risk management more broadly, we estimate the corresponding regressions as above but with industry fixed effects (48 industries following the Fama French classification<sup>20</sup>) instead of firm fixed effects. The results are reported in Table 6. Our data do not support the hypothesis that large firms manage risk to a lesser extent; with the exception of cash holding, none of the coefficients on the proxy for size,  $\ln(\text{Assets})$ , is negative and statistically significant, which is what we would expect if large firms managed risk to a lesser extent. The results instead support the notion that *larger firms engage more in risk management*, in some sense deepening the puzzle of the relation between risk management and size. We will return to this issue in our model-based discussion below.

[Table 6 about here]

### 4.3 Analysis with indicator variables of risk management

We may be interested in not only understanding how much a particular risk management practice is discussed, but also if it is discussed at all. To examine this, we use regressions that rely on indicator variables that take the value one if a particular form of risk management is discussed and 0 if it is not. The estimation uses linear probability. Column 1 of Table 7 uses the continuous measure of cash holding as the dependent variable. We note that a firm reporting the use of derivatives, credit lines, or diversification is associated

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tantamount to a concave utility function). However, risk aversion is only one reason for why the value of the firm can be a concave function of shocks. Other reasons for concavity, which are not directly affected by a diversified ownership, are transaction costs of financial distress or convex tax schedules (Smith & Stulz, 1985) as well as the need to maintain sufficient funds to be able to access capital markets when there are financial constraints (Froot, Scharfstein, & Stein, 1993). Clearly, motivations may differ across firms and across time, and research has also established cases where other motivations play a role. For instance, in an early influential paper, Tufano (1996) finds evidence consistent with an important role for managerial risk aversion in determining use of derivatives among North American gold mining firms.

<sup>20</sup> Available at [https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data\\_Library](https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library).

with a lower level of cash holding. On average, a firm that discusses use of derivatives holds around 0.6 percentage points less cash—that is, a cash over asset-ratio of 20.9% rather than 21.5%. The negative relationship between cash holding and the other means of managing risk is also seen by the negative coefficient on cash holding in Columns 2–6.

[Table 7 about here]

In contrast, the analysis suggests that relationships between text-based measures of risk management are mostly positive. Out of 20 coefficients 13 are positive and statistically significant at the 5% level or higher (an additional two are positive and statistically significant at the 10% level). For instance, a firm that reports using insurance is around 3.8 percentage points more likely to report using derivatives. Table 7 is estimated with linear probability, which has the advantage of easy interpretation. In the Online Appendix we report logit and probit estimation results of corresponding regressions as in Table 7 and note that the pattern with a positive relation between text-based measures of risk management are clear also in these alternative estimations.

#### **4.4 Relation between different ways of managing risk: A simple model-based discussion**

Summarizing our investigation, results indicate that (i) firms that use one form of managing risk are more likely to also use other forms of risk management, (ii) a more intensive use of one form of managing risk is associated with less intensive use of other forms of managing risk (with the exception of insurance, derivatives, and credit lines that tend to be positively associated), and (iii) larger firms use all types of risk management tools more (apart from cash holding).

In the following section, we sketch a simple model to show how such a combination of findings could arise. Let us first present the motivation underlying the different ingredients of the model. Economies of scale and scope in building up the ability to manage risk in a particular way is one part of the model. Several researchers have previously

hypothesized that fixed costs of building capacity for using derivatives can explain why large firms are more likely to use derivatives (see, e.g., Bodnar, Hayt, & Marston, 1998). We build on this intuition and also include economies of scope, which would imply, for instance, that if a firm takes the fixed cost associated with the capacity to use (and monitor) derivatives, this lowers its fixed costs of having the ability to apply other ways of managing risk.

The fixed costs for building capacity to manage risk with economies of scope across different ways of managing risk is consistent with the findings that large firms manage risk to a greater extent and cash holdings decrease with firm size. Cash holdings mostly have a negative relation with the dichotomous measures of risk management, which may reflect cash holding as a sort of default form of risk management: higher levels of cash holding is a risk management strategy that is available to all firms. On the one hand, cash holding is an attractive form of risk management as it has value across many states of the world, which limits the need for sophisticated analysis.<sup>21</sup> On the other hand, cash may be a costly form of managing risk as it ties up resources and is likely to lower investment.

Next, we focus on the cost of using a specific tool for a particular risk. In the analysis above, we did not attempt to model the various sources of risk a firm is exposed to. Instead we presented a bird's-eye perspective of different ways through which risk management methods are combined. Clearly, many nuances are glossed over at this level of detail, including that some risks may be handled in multiple ways with relative ease (for instance, exchange rate risk may be handled with derivatives, with long-term contracts with customers or suppliers, or by diversifying), all of which may be more or less appropriate for different horizons. Other risks, such as major property damage, may be much more suited for only one way of managing risk (insurance in this case). A broad implication of this is that some risks are relatively cheap/easy to manage with a specific tool, and the more risks that one attempts to cover with this particular tool, the more costly it becomes.

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<sup>21</sup>A currency hedge, for instance, only hedges against exchange rate exposure, whereas a large war chest in the form of greater cash holdings will loosen constraints almost irrespective of the source of shocks.

We formalize the intuition from the previous paragraph by assuming that there are convex costs of using a particular way of managing risk. This is consistent with a situation where it becomes increasingly costly to use a specific form of risk management the more risks that a firm seeks to use it for. Consider exchange rate risk, for instance. It may be easy for a U.S. firm to hedge transaction exposure to the euro at the 90-day horizon; however, longer horizons, less liquid currencies, and other factors may escalate marginal costs as the firm tries to hedge increasingly complex exposures. Increasing marginal costs may be linked to the costs of increasingly nonstandard contracts but also to a need for more accurate predictions and more sophisticated analysis.<sup>22</sup> Increasing marginal costs would imply that in a situation with multiple risks, and conditional on having taken the fixed cost of the capacity to use a particular tool of risk management, it is less costly to use several means of managing risk in conjunction, rather than exclusively relying on only one way of managing risk. As a specific form of risk management becomes more costly, we expect some substitution away from this way.<sup>23</sup>

To formalize these ideas, we consider a firm that lives for two periods (0 and 1). Period 1 operating profit is subject to risk both related to price  $p$  and quantity  $q$  shocks that are realized between the two periods. As a simple way to motivate risk management, assume that the firm has mean variance utility with risk aversion parameter  $\alpha > 0$ . The decisions of interest are hedging decisions taken in period 0, both as to the 0/1 margin (captured by fixed investments to gain capacity to use particular tools of managing risk) and the intensity of use (capturing how much to hedge, conditional on having the capacity). By taking a fixed cost  $F_p$ , the firm gains the possibility to hedge price risk via  $h_p$ . By taking the fixed cost  $F_q$ , it gains the capacity to hedge quantity risk by choosing  $h_q$ . If it pays  $F_b$ , it can use both hedging instruments and assume that there are economies of scope in these fixed costs so that  $F_b < F_p + F_q$ . We denote operating profits by  $\Pi$ . The firm's maximization problem in period 0 can then be expressed as:

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<sup>22</sup>Such logic is also consistent with evidence that relatively modest amounts are hedged, as shown in the seminal work of Guay and Kothari (2003).

<sup>23</sup>As noted, the exception to this pattern is the positive relation between credit lines, insurance, and derivatives. These ways of managing risk are purchased from financial institutions have a positive relation: if a firm uses derivatives, it is not only more likely to use insurance but also more insurance. A possible reason is that stronger financial sophistication may affect all these costs.

$$\max_{h_p, h_q, \mathbb{1}_i} E(\Pi(p, q)) - \frac{h_p^2 c_p}{2} - \frac{h_q^2 c_q}{2} - \sum_i \mathbb{1}_i F_i - \alpha var(\Pi(p, q), h_p, h_q) \quad (2)$$

where  $\mathbb{1}_i$  is an indicator variable that takes value one if the firm pays fixed costs  $i \in p, q, b$  that allows it to engage in hedging the respective risks.<sup>24</sup> If the firm pays  $F_b$ , its utility maximizing choices of  $h_p$  and  $h_q$  will be given by the first-order conditions, which can be expressed as

$$\begin{aligned} h_p &= -\frac{\alpha}{c_p} \frac{\partial var(\Pi(p, q), h_p, h_q)}{\partial h_p} \\ h_q &= -\frac{\alpha}{c_q} \frac{\partial var(\Pi(p, q), h_p, h_q)}{\partial h_q}. \end{aligned} \quad (3)$$

Under the natural assumption that hedging lowers variance, optimal hedges are both positive. Furthermore, they increase in the coefficient of risk aversion and decrease in the cost of hedging.

The equivalent of a cross-price effect is given by the response of  $h_p$  to  $c_q$  while keeping  $c_p$  as well as the expected values of  $p$  and  $q$  fixed. Using  $U$  to denote the utility function and a \* to denote the optimal choice, we thus perform comparative statics on  $U(h_p^*(c_q), h_q^*(c_q), c_q)$ . By totally differentiating the two first-order conditions in Equation (3), dividing by  $dc_q$  and writing in matrix form, we reach

$$\begin{bmatrix} c_p + \alpha \frac{\partial^2 var(\Pi(p, q), h_p, h_q)}{\partial h_p^2} & \alpha \frac{\partial^2 var(\Pi(p, q), h_p, h_q)}{\partial h_p \partial h_q} \\ \alpha \frac{\partial^2 var(\Pi(p, q), h_p, h_q)}{\partial h_q \partial h_p} & c_q + \alpha \frac{\partial^2 var(\Pi(p, q), h_p, h_q)}{\partial h_q^2} \end{bmatrix} \begin{bmatrix} \frac{dh_p}{dc_q} \\ \frac{dh_q}{dc_q} \end{bmatrix} = \begin{bmatrix} 0 \\ -h_q \end{bmatrix}. \quad (4)$$

Using Cramer's rule, we may then express the derivative of interest as the ratio of two determinants:

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<sup>24</sup>To avoid clutter, we have excluded the interaction between  $\mathbb{1}_i$  and  $h_i$ , but, as noted in the text, we assume that  $h_i$  can be nonzero only if the respective fixed cost is paid.

$$\frac{dh_p}{dc_q} = \frac{\begin{bmatrix} 0 & \alpha \frac{\partial^2 var(\Pi(p,q), h_p, h_q)}{\partial h_p \partial h_q} \\ -h_q & c_q + \alpha \frac{\partial^2 var(\Pi(p,q), h_p, h_q)}{\partial h_q^2} \end{bmatrix}}{\begin{bmatrix} c_p + \alpha \frac{\partial^2 var(\Pi(p,q), h_p, h_q)}{\partial h_p^2} & \alpha \frac{\partial^2 var(\Pi(p,q), h_p, h_q)}{\partial h_p \partial h_q} \\ \alpha \frac{\partial^2 var(\Pi(p,q), h_p, h_q)}{\partial h_q \partial h_p} & c_q + \alpha \frac{\partial^2 var(\Pi(p,q), h_p, h_q)}{\partial h_q^2} \end{bmatrix}}. \quad (5)$$

The second-order conditions for utility maximization require that the determinant of the denominator be negative, and hence the sign of the derivative will be determined by the sign of the determinant in the numerator. Thus,

$$\frac{dh_p}{dc_q} > 0 \text{ if } h_q \alpha \frac{\partial^2 var(\Pi(p, q), h_p, h_q)}{\partial h_p \partial h_q} < 0. \quad (6)$$

As  $h_q > 0$  (by assumption) and  $\alpha > 0$ , the two hedging instruments are substitutes if the cross-differential of variance with respect to hedging instruments is negative. Intuitively, this holds if the more that a firm hedges price risk, the less does additional hedging of quantity risk decrease variance.

To examine the 0/1 margin of hedging we present a simple numerical illustration. We are not attempting to solve for optimal hedges but simply want to illustrate the effects of different hedging choices on the mean and variance of post-hedging profits. Consider a firm with operating profits given by  $\Pi = (p - mc)q - F$ , where  $F = 5,000$ ,  $mc = 20$ , and  $p \sim N(120, 20)$  and  $q \sim N(100, 20)$ , respectively. Both price and quantity are thus taken to be exogenous and random. Using the utility function specified in Equation (2), consider the case where  $h_p = h_q = 0.5$  and  $F_p = F_q = 200$  and  $F_b = 220$ . Assume that hedging acts as a mean preserving shrinking of operating profits (apart from the direct cost of hedging captured by  $h_i$  and  $F_i$ ). Assume that purchasing  $h_p$  units of hedging decreases the variance of the price shock with the same amount, such that price is drawn from the distribution  $p \sim N(120, 20 - h_p)$ . Hedging of quantity risk is analogous.

We illustrate the probability density function of profits after hedging in Figure 1.

The solid blue line represents the case where there is no hedging, the red dashed line represents the case when there is full hedging of price (such that  $p = 120$ ), and the green dash-dot line is the case where there is some hedging of both quantity and price.

[Figure 1 about here]

Another examination of the same distributions is presented in Table 8. Given that hedging is costly, it is clear that the lower standard deviation in the case of hedging occurs at the cost of lower expected profits. The main point to observe, however, is that hedging with two instruments, as in the bottom row, is a more cost-effective way of lowering variance than fully hedging one risk while leaving the other unhedged, as in row 3. In a setting such as this, with economies of scope in the fixed costs of hedging and increasing marginal cost of hedging, it is thus no conundrum that a firm would use several instruments simultaneously, even if hedging instruments are substitutes—that is, if the price of one instrument increases, it will use more of other instruments.

[Table 8 about here]

## 5 CONCLUSIONS

Starting from a broad list of the different ways through which firms can manage risks, this paper used textual analysis of U.S. annual reports in the 10-K format to identify the prevalence of these different ways of managing risk. Manual reading of a sample of 10-Ks and annotating sentences yielded a data set that was used to train a classifier, which was then used to classify all the sentences appearing in Item 1 of the 10-Ks for fiscal years 1996–2015. The main tools of risk management that we examine, (use of derivatives, insurance, credit lines, long-run contracts, and diversification) are positively related, in the sense that use of one tool makes the use of another tool more likely. In contrast, higher cash holdings make it less likely that these methods are used. As to the

overall patterns, a negative relation dominates such that more intensive use of one way of managing risk is associated with less intensive use of alternative ways of risk management, apart from insurance, credit lines, and derivatives, which tend to move in tandem. The previous literature has mostly examined one or two ways of managing risk in isolation, and we believe that the broad evidence is useful in, for instance, understanding what previous results imply for the relation between firm size and risk management as well as for understanding the motivations for risk management.

A comparison with dictionary-based word counts indicates substantial promise for supervised learning methods as applied to 10-Ks. We conclude with a discussion of the potential lessons for future use of textual analysis of 10-Ks to examine issues of risk management. We found that even though there is no explicit requirement to discuss risk management in Item 1 in 10-Ks, in several dimensions, firms discuss risk management in a way that is amenable to automated text analysis. Topics such as derivatives, credit lines, insurance, and diversification were not only discussed relatively frequently but also often appeared in similar texts, which made it easier for the algorithm to identify them. A possible reason for this is that a discussion of specific risk factors, as mandated in Item 1A, quite naturally invites a discussion of the means used to manage the associated risk. Thus, a deliberation on using derivatives follows the discussion on exposure to the euro; discussion on liability insurance follows naturally from an examination of legal risks.

In line with this reasoning, manual reading suggests that much of the risk management discussion that we documented surfaces in the discussion on risk factors with the proviso that it may not be enough. For instance, Winston (2006) state that “although we have entered into an interest rate cap agreement that limits our interest rate exposure to increases in 30-day LIBOR over 9.17% on principal balances up to \$ 150 million outstanding debt under the GE Line, increases in interest rates up to this limit could increase our interest expense and adversely affect our cash flow.” This is an example of how, in a discussion that is required to examine well-specified risks, it is quite natural to also consider ways in which the respective risk is managed.

Risk management tools that are less likely to be linked to the type of reasoning “we

are faced with this risk, we do ‘that,’ but ‘that’ may not be enough” are more difficult to identify and, by impression from our reading, are less likely to be discussed at all. For instance, this concerns some aspects of operational hedging and of flexibility, which may be less clearly linked to a specific risk factor and more broadly linked to resilience and keeping options open. These may also be amenable to textual analysis and, possibly, one way to identify such sentences would be to examine the sources of risk in more detail. One indication suggesting potential in such a strategy is a positive correlation between our dictionary-based measure of flexibility and the text-based measure of product market fluidity as developed by Hoberg, Phillips, and Prabhala (2014). It may also be useful to focus manual reading on specific industries as the routes via which flexibility and operational hedging function as risk management are likely to depend on the industry under analysis. For airlines, operational hedging may, for instance, be about fuel efficiency (see, e.g., Treanor, Simkins, Rogers, & Carter, 2014). We chose to manually annotate two years quite far apart to allow for a long view, but it may well be that future work will aim to focus the manual annotation and analysis on narrower samples. Our first impression was that different sections of the 10-K are quite different in terms of wording and we therefore examined only Item 1. Applying supervised learning to the management discussion and analysis section of 10-Ks should be valuable in future work. The use of automated textual analysis to examine the decision environment of firms is still at a nascent stage, and applying the type of tools used here to other sources such as earnings conference calls or annual reports in other jurisdictions are just two examples of interesting future applications.

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Figure 1: Distributions of ex post profits under different hedging schemes

This figure presents density plots for ex post profits with different hedging practices across 10,000 draws on price and quantity, as described in the text.

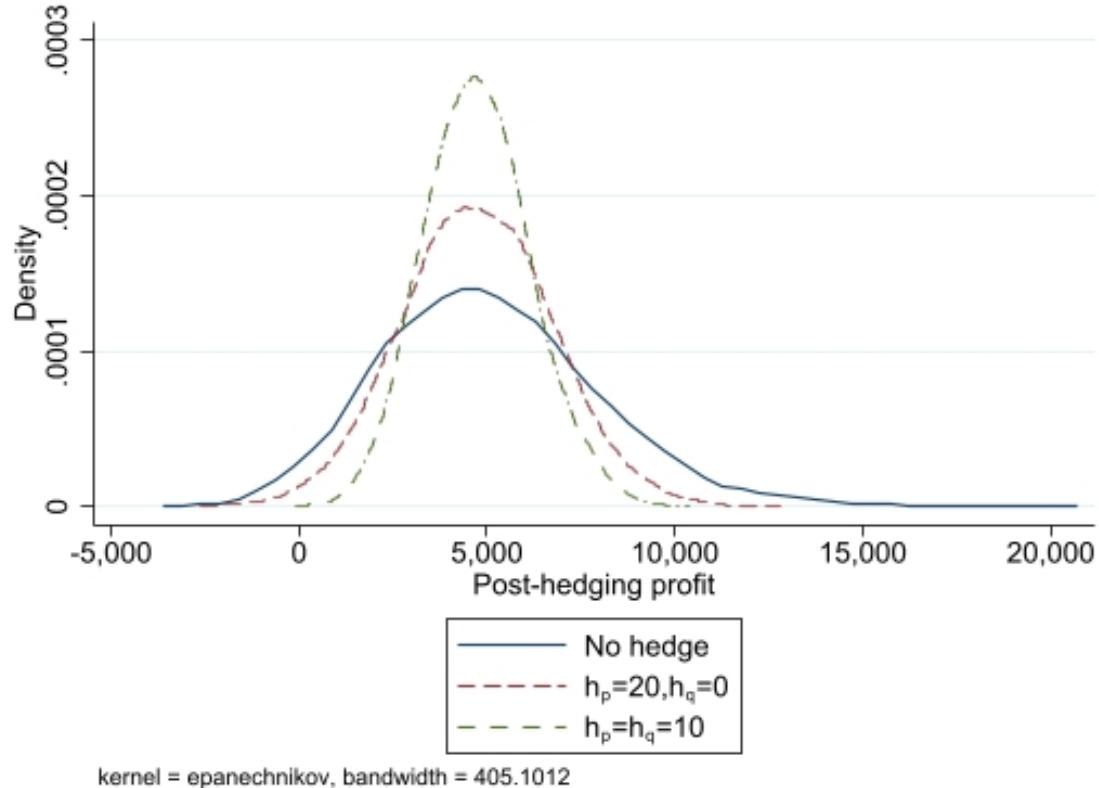


Table 1: Summary statistics of risk management measures

This table presents summary statistics for the main estimation sample (Tables 5–7) of the share of sentences in Item 1 of 10-Ks that discuss use (positive mentions) of the relative risk-management topic in the heading during fiscal years 1996–2015. Sentences are identified using a supervised learning algorithm, as described in the text.

Statistic	Cash	Derivatives	Insurance	Credit lines	Long-run contr.	Diversification
<i>Summary statistics overall</i>						
mean	19.960	0.194	0.503	0.494	3.367	4.000
sd	23.527	0.554	0.815	0.993	2.627	3.528
p5	0.329	0.000	0.000	0.000	0.287	0.326
p10	0.817	0.000	0.000	0.000	0.781	0.645
p50	10.254	0.000	0.120	0.000	2.747	3.077
p90	56.981	0.592	1.467	1.674	6.667	8.583
p95	74.996	1.119	2.062	2.505	8.412	10.944
N	48,477	48,560	48,560	48,560	48,560	48,560
<i>Summary statistics conditional on positive</i>						
mean		0.740	1.001	1.255	3.537	4.132
sd		0.874	0.907	1.245	2.579	3.508
p50		0.440	0.741	0.870	2.881	3.191
N		12,759	24,400	19,100	46,218	47,007
<i>Share of observations with positive values</i>						
mean		0.263	0.502	0.393	0.952	0.968

Table 2: Summary statistics on text-based measures of risk management (word counts)

This table presents summary statistics for the main estimation sample (Tables 5–7) of the share of words in Item 1 of 10-Ks that belong to dictionaries intending to capture the relative risk-management topic in the heading during fiscal years 1996–2015. Correlations are with text-based measures using a supervised learning algorithm.

Statistic	Deriv.(wc)	Insu.(wc)	Liquidity.(wc)	Oper. h.(wc)	Flex.(wc)	ERM(wc) × 1,000
mean	0.186	0.050	0.065	0.027	0.026	0.298
sd	0.135	0.102	0.082	0.035	0.054	5.634
p50	0.172	0.019	0.041	0.019	0.014	0.000
p95	0.419	0.201	0.216	0.087	0.089	0.000
p99	0.583	0.391	0.371	0.144	0.183	8.194
N	48,560	48,560	48,560	48,560	48,560	48,560
Correlation with:	Deriv- atives	Insur- ance	Credit lines			
	0.389	0.637	0.368			

Table 3: Cross-tabulation between text-based measure of derivatives use and Compustat based measure

This table presents a cross-tabulation of proportions of firm-fiscal year observations that are designated as derivative users employing the supervised algorithm that is used in the main analysis (rows) and based on Compustat (columns) where use of derivatives is implied by nonzero values of AOCIDERGL and/or HEDGEGL. Data from 2005 onward, 37,324 observations.

Derivatives use (text)	Derivatives use (CS)		
	0	1	Total
0	50.58	11.10	61.68
1	22.04	16.28	38.32
Total	72.62	27.38	100.00

Table 4: Relation between text-based measures of risk management and other measures of derivatives use, diversification, and use of credit lines

This table presents *t*-tests for comparison of the means of the text based measures in the left-most column across different comparisons. In Panel A Hedge in CS is 1 for observations where derivatives use is implied by nonzero values of AOCIDERGL and/or HEDGEGL in Compustat. In Panel B Single industry in CS is one when only one four-digit SIC industry is reported in Compustat segments, Multiind in CS if more than one four-digit SIC reported. In Panel C No futures versus Futures indicates whether there exist traded futures for the six-digit NAICS industry as detailed in Almeida, Hankins, and Williams (2017, Appendix B). In Panel D Credit line is one when the firm uses credit lines following Sufi (2009). In Panel E Hedge is one when Item 7A reports positive values for currency or commodity derivatives for a random sample of 10-Ks, see the Online Appendix for further discussion. Standard errors are in parentheses.

<i>Panel A</i>	All	No hedge in CS	Hedge in CS	Difference	<i>t</i> -stat ( <i>p</i> -val)
Derivatives	0.269 (0.003)	0.168 (0.003)	0.534 (0.009)	0.366 (0.007)	51.80 (0.00)
Derivatives(wc)	0.231 (0.001)	0.227 (0.001)	0.239 (0.001)	0.011 (0.001)	7.43 (0.00)
No Derivatives	0.030 (0.000)	0.030 (0.000)	0.028 (0.001)	-0.002 (0.001)	-1.68 (0.09)
N	37,324	27,103	10,221		
<i>Panel B</i>	All	Single ind. in CS	Multiind. in CS	Difference	<i>t</i> -stat ( <i>p</i> -val)
Diversification	4.000 (0.016)	3.498 (0.019)	4.817 (0.028)	1.318 (0.032)	40.67 (0.00)
N	48,650	30,071	18,489		
<i>Panel C</i>	All	No futures	Futures	Difference	<i>t</i> -stat ( <i>p</i> -val)
Derivatives	0.269 (0.003)	0.223 (0.003)	1.136 (0.030)	0.913 (0.014)	63.54 (0.00)
Derivatives(wc)	0.231 (0.001)	0.224 (0.001)	0.352 (0.004)	0.127 (0.003)	41.30 (0.00)
N	37,324	35,502	1,822		
<i>Panel D</i>	All	No credit line (Sufi)	Credit line (Sufi)	Difference	<i>t</i> -stat ( <i>p</i> -val)
Credit line	0.176 (0.004)	0.032 (0.003)	0.206 (0.003)	0.176 (0.004)	15.72 (0.00)
N	20,575	3,526	17,049		
<i>Panel E</i>	All	No hedge (7A)	Hedge (7A)	Difference	<i>t</i> -stat ( <i>p</i> -val)
Derivatives	0.606 (0.069)	0.437 (0.074)	0.851 (0.122)	0.414 (0.135)	3.06 (0.00)
N	100	59	41		

Table 5: Relation between different measures of risk management with firm fixed effects

This table presents OLS regressions with, as dependent variables, text-based measures of risk management using the share of sentences in Item 1 of 10-Ks that discuss use (positive mentions) of the particular risk-management topic in the heading during fiscal years 1996-2015. Sentences are identified using a supervised learning algorithm as described in the text. Cash, cash flow, leverage, market-to-book, and  $\ln(\text{Assets})$  calculated based on Compustat and winsorized at 1, and 99%. \*\*\*, \*\*, and \* indicate statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

Variables	(1) Cash	(2) Derivatives	(3) Insurance	(4) Credit lines	(5) Long-run c.	(6) Diversification
Derivatives $_{t-1}$	-0.348* (0.198)		-0.00405 (0.0157)	0.107*** (0.0414)	-0.0517 (0.0420)	-0.190*** (0.0585)
Insurance $_{t-1}$	-0.0260 (0.194)	-0.00254 (0.00948)		0.0559*** (0.0143)	-0.00668 (0.0346)	-0.190*** (0.0413)
Credit lines $_{t-1}$	-0.494*** (0.108)	0.0264*** (0.00573)	0.0237*** (0.00633)		-0.0285* (0.0170)	-0.163*** (0.0243)
Long-run c. $_{t-1}$	0.0147 (0.0738)	-0.00431** (0.00216)	-7.45e-05 (0.00351)	-0.00839** (0.00397)		-0.0259** (0.0109)
Diversification $_{t-1}$	-0.264*** (0.0503)	-0.00650*** (0.00225)	-0.0139*** (0.00285)	-0.0255*** (0.00369)	-0.0185** (0.00812)	
Cash $_{t-1}$		-0.000328* (0.000178)	-0.000487 (0.000299)	-0.00299*** (0.000432)	-0.00119 (0.00115)	-0.00628*** (0.00105)
Cash flow $_{t-1}$	-0.00963 (0.324)	-0.00301 (0.00243)	0.00144 (0.00506)	0.0145** (0.00621)	0.0467** (0.0228)	-0.0192 (0.0173)
Leverage $_{t-1}$	-3.926*** (0.604)	0.00792 (0.00773)	-0.0433*** (0.0122)	0.0538** (0.0225)	0.0521 (0.0531)	0.0948** (0.0437)
Market-to-book $_{t-1}$	0.131*** (0.0331)	0.000858*** (0.000241)	0.000536 (0.000492)	0.000224 (0.000537)	0.00168 (0.00237)	-0.00151 (0.00195)
$\ln(\text{Assets})_{t-1}$	-2.391*** (0.258)	0.0443*** (0.00782)	0.0155 (0.00945)	0.0139 (0.0127)	-0.0253 (0.0310)	0.192*** (0.0294)
Observations	48,478	48,560	48,560	48,560	48,560	48,560
R-squared	0.809	0.696	0.766	0.615	0.768	0.827
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES

Table 6: Relation between different measures of risk management with industry fixed effects

This table presents OLS regressions with, as dependent variables, text-based measures of risk management using the share of sentences in Item 1 of 10-Ks that discuss use (positive mentions) of the particular risk-management topic in the heading during fiscal years 1996–2015. Sentences are identified using a supervised learning algorithm as described in the text. Industry fixed effects following Fama-French classification with 48 industries. Cash, cash flow, leverage, market-to-book, and  $\ln(\text{Assets})$  calculated based on Compustat and winsorized at 1, and 99%. Robust standard errors clustered by firm. \*\*\*, \*\*, and \* indicate statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

Variables	(1) Cash	(2) Derivatives	(3) Insurance	(4) Credit lines	(5) Long-run c.	(6) Diversification
Derivatives <sub>t-1</sub>	-0.545*** (0.199)		-0.0376** (0.0175)	0.199*** (0.0314)	-0.0708 (0.0546)	-0.236*** (0.0474)
Insurance <sub>t-1</sub>	-0.967*** (0.185)	-0.0142* (0.00761)		0.0793*** (0.0136)	0.169*** (0.0409)	-0.284*** (0.0361)
Credit lines <sub>t-1</sub>	-2.645*** (0.207)	0.0619*** (0.00867)	0.0537*** (0.00860)		-0.0234 (0.0212)	-0.230*** (0.0264)
Long-run c. <sub>t-1</sub>	-0.0187 (0.0726)	-0.00244 (0.00189)	0.0160*** (0.00346)	-0.00329 (0.00268)		-0.153*** (0.0110)
Diversification <sub>t-1</sub>	-1.052*** (0.0561)	-0.00670*** (0.00176)	-0.0185*** (0.00215)	-0.0215*** (0.00225)	-0.119*** (0.00850)	
Cash <sub>t-1</sub>		-0.000367** (0.000146)	-0.00150*** (0.000303)	-0.00642*** (0.000284)	-0.00105 (0.00129)	-0.0250*** (0.00118)
Cash flow <sub>t-1</sub>	-1.355*** (0.274)	-0.00707*** (0.00247)	0.00273 (0.00583)	0.0495*** (0.00684)	0.0768*** (0.0232)	0.0594*** (0.0207)
Leverage <sub>t-1</sub>	-10.92*** (0.591)	0.0158** (0.00752)	-0.0343** (0.0136)	0.226*** (0.0231)	0.202*** (0.0585)	-0.220*** (0.0632)
Market-to-book <sub>t-1</sub>	0.140*** (0.0286)	-0.000177 (0.000220)	-0.00233*** (0.000549)	-0.00404*** (0.000692)	-0.00484* (0.00249)	0.0105*** (0.00196)
$\ln(\text{Assets})_{t-1}$	-1.264*** (0.0938)	0.0414*** (0.00271)	0.00963* (0.00500)	0.0208*** (0.00436)	0.0236* (0.0136)	0.300*** (0.0167)
Observations	48,478	48,560	48,560	48,560	48,560	48,560
R-squared	0.378	0.198	0.192	0.170	0.126	0.391
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

Table 7: Relation between different measures of risk management using indicator variables (0/1) to capture use of risk management tools

This table presents OLS regressions with, as dependent variables, text-based measures of risk management using the share of sentences in Item 1 of 10-Ks that discuss use (positive mentions) of the particular risk-management topic in the heading during fiscal years 1996–2015. Sentences are identified using a supervised learning algorithm as described in the text. All text-based measures defined as one if the topic is discussed by firm  $i$  in fiscal year  $t$ , and zero otherwise. Cash, cash flow, leverage, market-to-book, and  $\ln(\text{Assets})$  calculated based on Compustat and winsorized at 1, and 99%. Robust standard errors clustered by firm. \*\*\*, \*\*, and \* indicate statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

Variables	(1) Cash	(2) Derivatives > 0	(3) Insurance > 0	(4) Credit lines > 0	(5) Long-run c. > 0	(6) Diversification > 0
Derivatives $_{t-1} > 0$	-0.597** (0.297)		0.0352*** (0.00967)	0.0805*** (0.00959)	0.00764* (0.00441)	-0.000423 (0.00276)
Insurance $_{t-1} > 0$	0.382 (0.341)	0.0376*** (0.00929)		0.0847*** (0.00984)	0.0147*** (0.00452)	0.0154*** (0.00349)
Credit lines $_{t-1} > 0$	-0.885*** (0.266)	0.0564*** (0.00752)	0.0669*** (0.00794)		0.00679* (0.00350)	0.00189 (0.00290)
Long-run contracts $_{t-1} > 0$	-0.661 (0.490)	0.0168 (0.0120)	0.0318** (0.0140)	0.0302** (0.0136)		0.0235*** (0.00783)
Diversification $_{t-1} > 0$	-1.441* (0.846)	0.00131 (0.0128)	0.0572*** (0.0163)	0.0176 (0.0165)	0.0298** (0.0131)	
Cash $_{t-1}$		-0.000329* (0.000186)	-6.46e-05 (0.000218)	-0.00136*** (0.000214)	-0.000137 (0.000105)	-0.000348*** (0.000115)
Cash flow $_{t-1}$	-0.0137 (0.324)	-0.00292 (0.00285)	0.00229 (0.00361)	0.0113*** (0.00359)	0.00397 (0.00282)	-0.00124 (0.00301)
Leverage $_{t-1}$	-3.956*** (0.601)	0.0103 (0.00860)	-0.0290*** (0.00926)	0.0292*** (0.0107)	0.000910 (0.00595)	-0.00112 (0.00696)
Market-to-book $_{t-1}$	0.132*** (0.0331)	0.000419 (0.000329)	0.000299 (0.000441)	0.000895** (0.000428)	0.000232 (0.000299)	-0.000296 (0.000325)
$\ln(\text{Assets})_{t-1}$	-2.400*** (0.256)	0.0395*** (0.00499)	0.0123** (0.00576)	0.0215*** (0.00542)	0.00367 (0.00259)	0.00967*** (0.00257)
Observations	48,478	48,560	48,560	48,560	48,560	48,560
R-squared	0.809	0.650	0.723	0.637	0.528	0.553
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES

Table 8: Distributions of ex post profits under different hedging schemes, summary statistics

This table presents summary statistics (mean, standard deviation, coefficient of variation [sd/mean] and minimum) with different hedging practices across 10,000 draws on price and quantity, as described in the text.

hedging	mean	sd	sd/mean	min
Unhedged	5,060.676	2,890.172	.571	-3,202.024
$h_p = 10, h_q = 0$	4,826.154	2,280.187	.472	-2,953.203
$h_p = 20, h_q = 0$	4,731.901	2,019.036	.427	-2,646.010
$h_p = 10, h_q = 10$	4,751.908	1,427.428	.300	-115.793