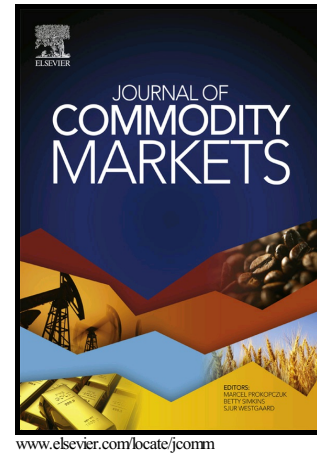


Author's Accepted Manuscript

A Review of the Literature on Commodity Risk Management

David A. Carter, Daniel A. Rogers, Betty J. Simkins, Stephen D. Treanor



PII: S2405-8513(17)30134-4
DOI: <http://dx.doi.org/10.1016/j.jcomm.2017.08.002>
Reference: JCOMM37

To appear in: *Journal of Commodity Markets*

Received date: 21 August 2017
Accepted date: 21 August 2017

Cite this article as: David A. Carter, Daniel A. Rogers, Betty J. Simkins and Stephen D. Treanor, A Review of the Literature on Commodity Risk Management, *Journal of Commodity Markets*, <http://dx.doi.org/10.1016/j.jcomm.2017.08.002>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting galley proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

A Review of the Literature on Commodity Risk Management¹

David A. Carter,^a Daniel A. Rogers,^b Betty J. Simkins,^a Stephen D. Treanor^c

^a *Department of Finance, Spears School of Business, Oklahoma State University, Stillwater, OK 74078-4011, USA*

^b *School of Business Administration, Portland State University, Portland, OR 97207-0751, USA*

^c *Department of Finance and Marketing, College of Business, California State University, Chico, Chico, CA 95929, USA*

Abstract

This paper analyzes research on commodity risk management by nonfinancial firms and provides a review of the findings to date. We discuss the theories and methodologies used including the models best suited for examining commodity risk management and exposure. In this study, we review how the research to date provides evidence to the following questions. Is commodity risk reflected in share price behavior? Is the use of commodity risk management tools (derivatives) associated with reduced risk? Is there a relationship between the use of commodity risk management and the value of the firm? What other factors are important to commodity risk management? Suggestions are provided for future research in this area.

JEL Classification: G32, L93

Key words: Firm value, Hedging, Risk management, Risk exposure, Commodities

*“If we don’t do anything, we are speculating. It is our fiduciary duty to hedge fuel price risk.”
(Scott Topping, quote in 2003 when VP Treasurer at Southwest Airlines)*

¹ Acknowledgements: We thank seminar participants for their helpful comments and suggestions at the China University of Petroleum in Beijing, Trinity College Dublin in Ireland, King Fahd University of Petroleum and Minerals in Saudi Arabia, Xiamen University in China, the 2016 International Workshop on Primary Commodity Markets at Dongbei University of Finance and Economics in China, the USAEE Conference in Tulsa, and the Energy and Commodity Finance Conference at ESSEC Business School in France (including the discussant, Monika Papiez). We also benefitted from comments provided by Tim Adams, Chitru Fernando, David Haushalter, Yanbo Jin, and Adriano Rampini.

“Hedging is a rigged game that enriches Wall Street.”

(Scott Kirby, then President of American Airlines Group quoted in March 20, 2016 Wall Street Journal article)

Introduction

We lead in with these two quotes to illustrate the disparity in senior management views of the wisdom of hedging commodity price risk within the same industry. Mr. Topping’s statement reflects a view that hedging commodity risk management is a financial policy that airlines should follow as part of their fiduciary duty. In fact, Southwest Airlines has continued to maintain an active fuel hedging program throughout most of the last 15+ years. However, risk management, including commodity risk management, varies dramatically across firms. Mr. Kirby’s statement implies that airlines should not attempt to manage fuel price risk by entering into derivative contracts because Wall Street has “an advantage” in terms of pricing contracts. Furthermore, in a Modigliani and Miller world with perfect capital markets, corporate risk management should not matter, so shareholders should be indifferent about whether firms hedge or not. In the real world with imperfect capital markets, academic research has shown that managing risk can be a value adding activity by reducing expected taxes, decreasing cash flow and earnings volatility, lowering the costs of financial distress, decreasing the cost of capital, and alleviating the underinvestment problem.

This paper analyzes research on commodity risk management by nonfinancial firms and provides a review of important findings to date to help us better understand these issues.²

Nonfinancial firms may approach commodity hedging differently than they approach, for

² There is another set of literature we do not cover that investigates other risk management topics. For example, Dewally, Ederington, and Fernando (2013) find that hedging is costly for producers when futures prices are depressed where there is imbalance in hedging. It is one of the few papers that addresses the market effects and costs of hedging. Other literature examines optimal hedge ratios, stochastic programming and risk decisions, VaR, CVaR, and related topics. For more information on areas, see Tomek and Peterson (2001), Fleten, Wallace, and Ziemba (2002), Gerner and Ronn (2013), among others. We also exclude research on the use of insurance contracts in risk management such as Cornaggia (2013), who studies the agricultural industry.

example, interest rate and currency hedging. Anecdotal evidence, surveys, and studies indicate that some managers may have opinions about the direction of future commodity prices which influence their hedging. Yet managers are less likely to have a view about future interest rates or exchange rates. Therefore, we believe that a review of commodity risk management research is very valuable to the literature.

Within the corporate risk management area, empirical research in recent years has gravitated towards specific industries with an emphasis on commodity price risk management: gold mining, oil and gas, airlines, and electric and gas utilities.³ A large reason for this focus is due to a change in data availability. Accounting requirements (SFAS 133, IAS 39) regarding corporate accounting and disclosure of derivative holdings have emphasized disclosures about market values of derivatives as assets or liabilities.⁴ However, in the process, these same accounting requirements de-emphasized disclosures regarding notional values of derivative contracts. While the market value of derivatives is certainly an important piece of information regarding corporate disclosure, notional values were previously used to decipher how much firms were hedging. Without notional value disclosures, the ability of academic researchers to study the extent of hedging by nonfinancial firms has been significantly reduced in the modern accounting disclosure environment of the last 15+ years. Fortunately, SEC disclosure requirements about risk exposures have allowed researchers to continue to learn about hedging in the industries we mention above. We discuss the methodologies used including the models best suited for examining commodity risk management and exposure.

³ To our knowledge, there is only one commodity risk management paper that examines utilities, Pérez-González and Yun (2013) so we mention this industry for completeness, This study examines the use of weather derivatives. A number of papers examine the other industries

⁴ The effective dates of SFAS 133 and IAS 39 were June 15, 2000, and January 1, 2001, respectively.

Better understanding the benefits of commodity risk management is not only helpful to nonfinancial firms but also highly relevant to regulators globally. For example, after the 2008 financial crisis, derivatives became a controversial part of the financial landscape. Government regulators imposed greater restrictions on these markets through the Dodd-Frank Wall Street Reform and Consumer Protection Act in the U.S. and similar legislation and regulations in other G20 nations. The restrictions included higher margin requirements, mandated clearing, and forcing over-the-counter (OTC) derivatives onto exchanges. But in so doing, corporate hedgers, which comprise less than 10% of the OTC markets, were also impacted. As Tom Deas at FMC Corporation states: *“Forcing end-users to put up cash for fluctuating derivatives valuations means less funding available to grow their business and expand employment. The reality treasurers face is that the money to margin derivatives has to come from somewhere and inevitably less funding will be available to operate their businesses.”*⁵

In this study, we investigate how the research to date provides evidence to help answer the following questions and also provide suggestions for future research. To our knowledge, no other study has been performed at this level of detail on commodity risk management.

- Question 1: Is commodity risk reflected in the equity share price returns or behavior?
- Question 2: Is the use of commodity risk management tools (derivatives) associated with reduced risk?
- Question 3: Is there a relationship between the use of commodity risk management and the value of the firm?
- Question 4: Are there other factors that affect a firm’s decision to manage commodity price risk?

This paper proceeds as follows. The next section presents a summary on theories of risk management and the following section discusses methodologies used to exam the four questions in commodity risk management. After this, results are presented on what we know from

⁵ For more information on this topic, see Popova and Simkins (2015).

commodity risk management research to date. Finally, a conclusion is provided with suggestions for future research.

Theories of Risk Management

Corporate risk management theory begins with the Modigliani and Miller (1958) perfect capital market framework (i.e., “hedging has no effect on firm value”), then introduces market imperfections that imply risk management can alter firm value. Table 1 summarizes 15 of the leading theoretical papers on corporate risk management and provides the journal, year, authors, summary of what was examined and theoretical findings. In this section, we discuss selected theoretical frameworks that help us understand factors that may make risk management valuable (or not).

The earliest theoretical paper that specifically addresses hedging is Stulz (1984), who presents a model where value-maximizing firms pursue active hedging policies. Stulz derives optimal hedging policies for risk-averse agents in the presence of uncertainty in commodity prices. This paper sets the stage for subsequent research investigating corporate risk management.

Smith and Stulz (1985) introduce an expected financial distress costs framework to motivate corporate risk management. Basically, they argue that firm value equals the present value of expected cash flows less the present value of expected distress costs. Expected distress costs are a function of distress probability and the costs of distress if it is incurred. To the degree that corporate risk management activities reduce the probability of distress, expected costs of distress decline and firm value is increased.

Froot, Scharfstein, and Stein (1993) extend the corporate risk management literature by introducing corporate risk management as a financing mechanism that helps mitigate the

financial constraints faced by firms. As an example of their framework, consider an airline company that has the opportunity to buy valuable assets following a period of rising fuel prices. If unhedged against rising oil prices, the company is likely to require outside funds to finance the investment opportunity. Given higher oil prices, the airline company's financial situation may be looked upon poorly by potential investors. Any additional premium required by investors because of current unfavorable economic conditions to the airline company may cause the company to forego the investment opportunity because of poor financing terms. If, on the other hand, the airline company had entered into risk management contracts in advance of the rising oil prices, then the investment opportunity is more likely to be funded (either through the positive cash flow resulting from the risk management contracts or because investors do not impose poor financing terms because of the firm's risk management strategy). In essence, the potential value lost by the failure to invest because of a lack of financing is a cost of distress. If hedging can reduce the probability of failing to invest, then risk management has positive value implications for the firm. Another way of stating this point is that hedging may allow a firm to reduce outside financing requirements when investors require the highest returns.

Hedging can conceivably have negative value implications. Tufano (1998b) introduces manager-shareholder agency costs into the Froot et al. (1993) model. In his model, he assumes that managers can privately capture the value created from an investment project. Because investors are aware of this ability, they may refuse to provide capital. To the degree that hedging provides cash flows (assuming risk management contracts are in-the-money), managers may be able to invest in these wealth-diverting projects.

Rampini, Sufi, and Viswanathan (2014) build on Rampini and Viswanathan's 2010 and 2013 papers to extend the theory to commodity price risk management and then empirically

examine fuel price risk management by airlines. (Note: Their empirical results are discussed later in our paper.) Rampini, Sufi, and Viswanathan argue that risk management theories incorporating financial constraints ignore collateral trade-offs. Their model assumes that financial constraints motivate risk management behavior and that all promises must involve collateral. This dual set of assumptions implies that firms face a trade-off of having collateral available for financing obligations (debt) and risk management obligations (derivatives). As a result, firms facing greater financial constraints employ less risk management because collateral needs for debt obligations (which finance investment) are more valuable. The implication of their theory is that risk management is a positive function of corporate net worth (i.e., excess of asset value less liability value).

Discussion to this point has focused on risk management motivations primarily stemming from risk management's interaction with financing and investment choices. Much of the theory and empirical literature has focused on these arguments. However, there is also a stream of theory that motivates risk management from a tax perspective. We briefly discuss this literature below.

Smith and Stulz (1985) argue that reducing the volatility of taxable income generates greater firm value if the firm faces a convex tax function. As a result, a hedging policy that reduces volatility of taxable income will be valued more by shareholders of firms facing more convex tax functions. This particular motivation has not been well-supported in empirical literature. Graham and Rogers (2002) provide the most comprehensive analysis of the tax convexity hypothesis, and find no evidence that corporate hedging is driven by these tax benefits. To our knowledge, very little, if any, evidence has been shown to empirically support the tax convexity hypothesis as a driver of variation in hedging.

A different type of tax argument for risk management comes from Leland (1998). If firms trade off expected tax benefits of debt with expected costs of financial distress, an optimal level of debt exists for a given firm. As mentioned previously, hedging provides a firm with the ability to reduce expected distress costs by lowering the probability of distress. This may allow the hedging firm to optimally choose more debt, and with this higher debt level, achieve greater expected tax benefits.

Finally, managerial risk aversion has been argued as a driver of corporate risk management behavior. In addition to considering financial distress and tax arguments for hedging, Smith and Stulz (1985) also propose an argument focused on managerial risk aversion and its interaction with firm-related wealth and compensation structure. The basic idea of their framework is that linear forms of payout to managers as a function of firm value (i.e., stock) are concave in a risk-averse manager's utility function. Thus, shares of stock owned by managers are more likely to induce corporate hedging. To offset this risk aversion effect, firms may award stock options to make managerial reward functions less linear and more convex (thus offsetting the concavity resulting from risk aversion). Their empirical implication is that firms run by managers that own more options (as opposed to shares of stock) are less likely to hedge.

Figure 1 illustrates the structure of the literature on commodity risk management and the theoretical motivations for hedging we have discussed. Next, we briefly describe common methodologies used in research to date.

Methodologies Employed

Question 1: Is commodity risk reflected in the equity share price returns or behavior?

To answer this question, researchers most often employ an augmented market model, in

which an index representing the returns on the commodity of interest are included in addition to the returns on the market portfolio. Equation (1) illustrates this model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i R_{b,t} + \varepsilon_{i,t} \quad (1)$$

where $R_{i,t}$ is the return on stock i for time period t , $R_{m,t}$ is the return on the market portfolio, typically the CRSP equally-weighted portfolio, for time t , $R_{b,t}$ is the return to commodity index b (e.g., return on oil prices), for time t , and $\varepsilon_{i,t}$ is the idiosyncratic error term.⁶

Using an augmented market model allows for the investigation of the firm's risk from two different sources. The parameter, β_i , captures the variation in risk due to changes in the broad stock market while the exposure to commodity price risk is measured by γ_i . If γ_i is different from zero, this provides evidence that the firm is significantly exposed to the commodity price risk being studied. Typically, γ_i is expected to be positive for producers of commodities since producers' cash flows increase when commodity prices increase. Similarly, γ_i is expected to be negative for users of commodities since this causes cash flows to decrease from due to higher expenses. Exposure is analyzed at the firm level and also on industry portfolios.

Question 2: Is the use of commodity risk management tools (derivatives) associated with reduced risk?

The most frequently used technique is to investigate whether hedging affects the size of the exposure coefficient, $\gamma_{i,t}$, for firm i in time period t , while controlling for other factors, as illustrated in Equation (2):

$$|\gamma_{i,t}| = \alpha_0 + \alpha_1 \text{Hedge}_{i,t} + \sum_{j=1}^N \beta_j \text{Control Variables}_{i,t} + \varepsilon_{i,t} \quad (2)$$

⁶ Bodnar and Wong (2003) recommend using the equal-weighted index in CRSP. They find when examining exchange rate exposures that using the value-weighted index can distort the sign and size of the resulting exposures because of an inherent relation between market capitalization and exposure. The equal-weighted index does not cause this bias.

Equation (2) illustrates a common methodology employed where time period t , can be for a year or longer period of time. “Hedge” is the hedging variable that can be measured in a variety of ways (e.g., a dummy variable indicating hedging behavior by the firm, the percent of commodity hedged, etc). Common control variables include size (usually measured as the natural logarithm of total assets), the debt ratio (used as a standard measure of financial constraints), the credit rating (to proxy for firm risk), and measures of operational strategies (to measure a firm’s ability to make an adjustment in operations, often referred to as operational hedges, to reduce exposure).⁷ It should be noted that control variables tend to be industry-specific variables in the studies. For example, Tufano (1998) included gold price and gold price volatility, production quantity, and % of assets in mining, among other control variables, and his paper has the most comprehensive set of control variables.

A potential complication when investigating the relation between exposure and hedging is endogeneity. While hedging behavior by the firm may affect its exposure to a commodity, it may also be that the level of exposure affects the hedging decision. To address this issue, Treanor, Simkins, Rogers, and Carter (2014) use simultaneous equations and instrumental variables to control for endogeneity. Studies in more recent years are expected to employ more complex econometric modeling to address statistical challenges such as endogeneity of independent variables.

Question 3: Is there a relationship between the use of commodity risk management and the value of the firm?

Tobin’s Q is the most frequently used measure of a firm’s value in research to date. A positive relationship between commodity risk management and the value of the firm, while

⁷ For example, Treanor, Simkins, Rogers, and Carter (2014) use the diversity of an airline’s fleet, fleet fuel efficiency, and fuel pass-through agreements as measures of operational hedges when analyzing jet fuel exposure in the airline industry.

controlling for other factors, provides evidence that commodity risk management adds value. Equation (3) illustrates the relationship between firm value and commodity hedging behavior:

$$\text{Ln}Q_{i,t} = \alpha + \beta_1 \text{Hedge}_{i,t} + \sum_{j=2}^N \beta_j \text{Control Variables}_{i,t} + \varepsilon_{i,t}, \quad (3)$$

where $Q_{i,t}$ represents Tobin's Q for firm i at time t (the natural logarithm of Tobin's Q is often used). Other variable notations are as previously described. Common control variables employed include size, the debt ratio, the credit ratio, a measure of liquidity, a measure of dividend policy, among others. Carter, Rogers, and Simkins (2006) have the most comprehensive set of control variables.⁸ Econometric methods employed include ordinary least squares (OLS) with robust standard errors, feasible generalized least squares (FGLS) to control for heteroskedasticity, and fixed effects. It is important to note that industry specific studies can help overcome endogeneity issues when the correlation between hedging and firm value may be impacted by sector growth and managerial ownership (see Coles, Lemmon, and Meschke, 2012).

Question 4, Are there other factors that affect a firm's decision to manage commodity price risk?

A number of papers investigate various managerial incentives for hedging. Researchers use a variety of economic models used due to the breath of the hypotheses tested. For brevity, we provide two examples to highlight this area of research.

Adam, Fernando, and Salas (2017) investigate the widespread practice of selective hedging documented in surveys, in which managers incorporate their market view into the firm's hedging decisions. The following general relationship is explored as shown in Equation (4):

$$\text{Selective hedging} = f(\text{firm characteristics, board characteristics, CEO tenure, and institutional ownership}). \quad (4)$$

⁸ For example, Carter, Rogers, and Simkins (2006) include firm size, a dividend indicator, leverage, cash flow, capital expenditures, the Z-score, credit ratings, advertising, and cash balances as control variables. Jin and Jorion (2006) include firm size, ROA, CAPX, Leverage, and dividends as control variables.

Rampini, Sufi, and Viswanathan (2014) study the airline industry to investigate the trade-off between risk management and the financial constraints of firms. This trade-off is referred to as dynamic risk management and is investigated using various specifications of the model described in Equation (5):

$$\text{Fraction of next year fuel hedged} = f(\text{net worth, instrumental variables}). \quad (5)$$

We describe Rampini, Sufi, and Viswanathan's (2014) research in more detail in the next section.

What Have We Learned from Empirical Research in Commodity Risk Management?

Tables 2 and 3 provide very short summaries of selected papers addressing commodity risk management by nonfinancial firms for commodity users (Table 2) and commodity producers (Table 3). In Table 4, we summarize papers in which commodity derivatives usage is a portion of the data sample (thus firms could not be classified specifically as users or producers) along with interest rate and/or currency risk management. Each table provides the journal, year, authors, summary of what was examined, and main findings. In addition, the total number of citations according to Google Scholar as of August 20, 2017 is also listed with the main findings, to provide the reader with a gauge of the relative influences of the papers.

Table 2 illustrates that prevailing research studying commodity risk management from a user perspective utilizes almost exclusively airline industry samples (seven studies) with one study from the oil refining industry.⁹ Table 3 summarizes 17 studies of commodity producers. Five studies analyze oil and gas firms and eleven investigate gold mining companies (one recent

⁹ MacKay and Moeller (2007) is classified as both a "user" and "producer" paper. They study firms from the oil refining industry, and analyze risk management from a revenue perspective (e.g., these firms produce refined petroleum products such as gasoline and can hedge these risks) and from an expense perspective (e.g., these firms buy crude oil as an input into the refining process).

paper included in our list studies a range of energy and metal commodities, including gold, and one other utilizes a sample of oil refiners). Table 4 provides summaries of 11 fairly influential articles from the last 20 years that are focused on more broad-based exploration of factors impacting overall risk management (not simply commodity risk management) including operational hedges, corporate governance structure, managerial overconfidence, product market dynamics, and cash holdings, among others. We note that the samples in most of these papers are drawn from U.S. firms in the 1990s.¹⁰ This is a function of the fact that analyses of more recent data on the extent of hedging is no longer possible in the U.S. because of data limitations associated with how most companies disclose derivatives positions in the post-FAS 133 era.

Table 5 provides a classification regarding which of the four questions are addressed by each of the 24 papers listed in Tables 2 and 3. These studies reflect empirical research focused purely on commodity risk management, thus these are of more direct interest than the papers listed in Table 4. Some papers are classified as addressing two, rather than only one, of the questions we pose.

Most of the research efforts in commodity price risk management have been focused on issues revolving around whether hedging is valuable (Question 3 with 11 papers) or factors that affect hedging (Question 4 with 11 papers). Slightly less work has been accomplished to address questions around whether firms are exposed to commodity price risk (Question 1 with 6 papers) and whether hedging affects stock price performance (Question 2 with 7 papers). In fact, Questions 1 and 2 are typically studied jointly.

¹⁰ We include DeAngelis and Ravid (2017) in this list despite its lack of influence yet because we view this research as potentially valuable in the general hedging literature in the future. Their work differs from the other articles listed in Table 4 on two levels: 1) they address commodity hedging, but do so in a more general way than conducted in research shown in Tables 2 and 3, and 2) their data is slightly more recent (the sample time frame is 2001 – 2005) because they limit themselves to defining commodity hedging with a dummy variable rather than attempting to use notional values.

Numerous authors have contributed to empirical work in commodity risk management during the last 20+ years. The most prolific author in the literature is Tim Adam with five unique papers among the 24 in our list. He has co-authored three of these papers with Chitru Fernando. There is no overall dominating journal in which empirical research on commodity risk management is published. However, eight papers each are published in the *Journal of Finance* and *Journal of Financial Economics*, which means that these two journals published two-thirds of these 24 studies. Table 5 also shows whether the hedgers studied are producers or users and which industry from which the sample is drawn. Each of the questions addressed have been analyzed from both the producer and user perspective and all three industry classes have been utilized.

What have researchers learned about corporate risk management from analyzing samples of commodity users and producers? We focus on a set of eight influential articles as identified by number of citations and average citations per year since publication. The articles and citation counts are shown in Table 6. We choose to discuss the influential papers chronologically to provide the reader with a sense of the evolution of what researchers are choosing to study as time passes.

Early (meaning the 1990s and early 2000s) empirical work on corporate risk management tended to be focused on the question of “what factors affect hedging policy?” (i.e., Question 4). This question is largely addressed by testing hypotheses formulated from the theoretical work in corporate risk management. With respect to research utilizing strictly commodity samples, Tufano (1996) and Haushalter (2000) have been the most influential papers. Some subsequent research explores this question as well, but the primary focus lies elsewhere.¹¹

¹¹ From our list of influential papers, Carter, Rogers, and Simkins (2006), Brown, Crabb, and Haushalter (2006), and Rampin, Sufi and Viswanathan (2014) provide some discussion and analysis to the issue of factors driving differences in hedging policy.

Tufano (1996) analyzes data from North American gold mining firms to determine what factors affect variation in the extent of gold price risk hedged by firms. Tufano constructs explanatory variable to explore hypotheses associated with both hedging as a value-maximizing policy and with hedging as a policy driven by managerial risk aversion. He concludes that differences in hedging are affected primarily by differences in managerial characteristics, especially the nature of executive compensation and wealth. His most cited finding is that hedging by gold mining firms is negatively affected by the extent of option compensation of company executives while hedging is positively affected by direct stock holdings.

Tufano (1998a) offers a “companion” (Tufano’s description, not ours; see page 1016 of his article) piece of research to his study analyzing variation in gold mining firm hedge ratios. In this article, he studies variation in gold price betas among the sample firms over approximately the same time frame as his study of hedging. Hedging of gold price risk is one of the most powerful explanatory variables in his models. Specifically, Tufano finds that gold price betas for gold mining firms are lower by 0.65 – 0.96 for firms that hedge all of their production as compared to firms that engage in no hedging of production. Given that the mean level of gold price beta is 2.21 in his sample, hedging clearly has an economically significant effect on the sensitivity of gold mining stocks to changes in gold prices. We interpret Tufano (1998a) as one of the two influential studies in commodity risk management illustrating that commodity price risk is reflected in stock market prices (Question 1) and that commodity hedging reduces equity risk (Question 2). The other influential study, Jin and Jorion (2006), is discussed shortly.

Haushalter (2000) studies U.S. oil and gas producers’ hedging policies from 1992 – 1994. Much like Tufano (1996), Haushalter utilizes explanatory variables to explore hypotheses associated with financial contracting costs, tax structure, and managerial risk aversion. As

opposed to Tufano's results in the gold mining industry, Haushalter finds results suggesting that financial contracting costs are a primary determinant of how much firms hedge. In particular, he finds evidence that firms with higher debt ratios hedge more, and that better access to capital (as evidenced by the presence of a credit rating from S&P) is associated with less hedging by firms. Holding all else equal, a higher credit rating is also associated with less hedging in his sample firms. On the other hand, he does not find evidence consistent with Tufano's findings regarding managerial risk aversion.

A significant portion of the influential papers in commodity risk management appeared in 2006. These studies reflect a change in focus away from the factors affecting hedging to more emphasis on whether hedging is a valuable financial policy for firms. To some degree, a motivation for these studies came from Guay and Kothari (2003). They suggested that research studying derivatives and hedging and value in other realms (such as hedging with currency derivatives) as likely being overstated in terms of economic significance. Commodity risk management may be less likely prone to their criticism because of the significant exposures faced by commodity producers (and users, e.g. in the case of airlines). Additionally, Tufano's finding that hedging was likely driven more by managerial risk aversion than by value-maximizing factors implied that managers may be inclined to hedge for more behavioral reasons (i.e., selective hedging).

Before we move on to the question of the value effect of hedging, it is worth noting that Carter, Rogers, and Simkins (2006) also analyzed the determinants of jet fuel hedging by airlines using data from 1992 - 2003. They highlight an important difference relative to Haushalter (2000) and Tufano (1996). Contrary to the positive relation found by Haushalter (2000), Carter, Rogers, and Simkins find that more leverage and weaker credit ratings are associated with less

fuel hedging across airline companies. Overall, a striking difference emerges in findings between three different articles (Tufano (1996), Haushalter (2000), and Carter, Rogers, and Simkins (2006)) that analyze hedging in three different industry settings. Specifically, results of analyses of corporate hedging policy variation may often not generalize when researchers study different industries. The difference may be driven by differences between the producer versus user perspective of commodity risk management. Additionally, there may be time-period aspects of economic circumstances associated with differing sample time periods that could drive differences in results.

Is corporate hedging valuable (Question 3)? This has been a contentious issue among finance researchers since the publication of Allayannis and Weston (2001) who concluded that foreign currency hedging warranted an approximate five percent premium to firm value, on average, relative to those firms that did not hedge their currency risk. While some studies have found positive evidence that commodity risk management adds value, overall the evidence is mixed. The most promising studies to date have been industry studies in which both the commodity exposure is important and there is heterogeneity in hedging practices. This also helps overcome endogeneity problems (see Coles, Lemmon, and Meschke, 2012). The seminal study of commodity risk management by commodity users is Carter, Rogers, and Simkins (2006), who find that fuel price hedging by airlines was associated with significantly higher firm values. More specifically, the study examined 29 U.S. airlines over the period 1992-2003 and found 1) the stock prices of all the airlines were highly sensitive to fuel prices and 2) the prices of the airlines that hedged traded at a 5 - 10% premium over those that did not. Furthermore, they highlight that the likely source of the value premium comes from being able to fund valuable investments during periods of higher fuel prices. While the value effect is higher than found in Allayannis

and Weston (2001), they argue that there are reasonable economic arguments for a larger value premium to hedging in the airline setting. First, the volatility of jet fuel price is much greater than that of currencies -- about 2.5 times greater when measured over the sample time frame. Second, jet fuel costs comprise a large proportion of airline operating expenditures. Third, increases in jet fuel costs are very difficult to pass through in the form of fare increases.¹² Other airline-related studies shown in Table 2 tend to illustrate positive relations between hedging and value.

As a contrast to the airline industry evidence, Jin and Jorion (2006) studied the hedging activities of 119 U.S. oil and gas producers from 1998-2001 and concluded that, while hedging reduced the firm's stock price sensitivity to oil and gas prices, it did not appear to increase value. As the authors conclude, "...one might even argue that investors take positions in oil producers precisely to gain exposure to oil prices. If so, an oil firm should not necessarily benefit from hedging oil price risk." It is important to note that Jin and Jorion's sample consists mainly of oil and gas producers that are non-diversified (see Table I on page 899 where exploration and production is the dominant segment, accounting for 94%/100% mean/median of total sales and 96%/100% mean/median of total assets). In an unpublished working paper, Lookman (2004) finds that exploration and production firms who are diversified exhibit a positive relation between commodity hedging and firm value.

Concurrently with studies of hedging and firm value, other research on factors driving hedging policy reflects curiosity about selective hedging. Stulz (1996) introduces the concept of

¹² Consider the hedging results for two major airlines during the time period of their study, American Airlines and Southwest Airlines. At the end of 2004, AMR (parent company of American Airlines) had hedged roughly 5% of its 2005 fuel requirements and, as a result, expected to pay \$1.3 billion more for jet fuel in 2005 than in 2004 (a considerable amount, considering that 2004 revenues were \$18.6 billion and the net loss for that year was \$761 million). By contrast, Southwest Airlines' aggressive hedging program (which involved hedging over 80% of its 2005 fuel requirements, with some contracts extending up to six years) saved the firm over \$1 billion on fuel since 2000, allowing it to make important capital investments when strategic opportunities arise.

selective hedging as the possibility that corporate hedgers may alter hedging policy to fit their view of expectations about the future price path associated with a hedgeable risk exposure. Beginning with Brown, Crabb, and Haushalter (2006) and Adam and Fernando (2006), more of the empirical commodity hedging research has attempted to better understand why we observe non-stability in hedging policy by firms over time and whether selective hedging adds additional cash flow and value to firms.

The focus on the benefits of hedging in the gold mining industry have largely looked at the effect of hedging on derivatives cash flows (thus, there is indirect evidence on whether hedging adds value in this industry). For example, Adam and Fernando (2006) show that gold mining firms exhibit positive cash flows resulting from derivatives positions with no evidence that systematic risk increases. In other words, they argue that selective hedging is driven by the presence of risk premia in gold derivatives markets. However, they find that the practice of selective hedging does not produce meaningful cash flow gains on a persistent basis. There are no clear winners and losers based on selective hedging.

An interesting difference between these two studies of selective hedging is the way in which they view gold prices as affecting selective hedging. Brown, Crabb, and Haushalter (2006) find that their sample firms tend to increase hedge ratios when gold prices are higher, so mining firms might be trying to lock in higher margins through selective hedging.¹³ In effect, their story is one of market timing and possible mean-reversion in gold prices. On the other hand, Adam and Fernando (2006) base their analysis on risk premiums in derivatives markets. They find that the cash flow gains achievable come from the observation in their sample, on average, that gold mining firms are able to sell gold at forward prices that are higher than the realized spot

¹³ Treanor, Rogers, Carter, and Simkins (2014) analyze exposure (i.e., Question 1) and the effect of hedging on firm value (Question 3). As part of their analysis, they look at the effect of fuel price levels on both exposure and on hedging amounts. They find that fuel price levels are positively related to exposure and to hedging.

gold prices occurring in the future. However, in both studies, the authors find that persistent gains are very hard to achieve!

Rampini, Sufi, and Viswanathan (2014) provide a different perspective on results from Carter, Rogers, and Simkins (2006). They argue that the availability of collateral is a key element in hedging decisions, and that there is a trade-off in terms of making collateral available for debt contracts as opposed to derivative contracts. The empirical implication is that financially constrained firms are limited in their ability to use collateral for risk management (because of their need to have collateral available on outstanding debt), so these firms hedge less. As the reader may recall, Carter, Rogers, and Simkins found that the extent of hedging by U.S. airlines was positively related to credit ratings and negatively related to debt. Rampini, Sufi, and Viswanathan (2014) construct a number of measures of “net worth” and show that these measures are positively associated with hedging by U.S. airlines during 1996 – 2009. However, we note that their arguments do not explain why we observe positive relations between debt and hedging in other sample environments (e.g., Haushalter (2000) in the oil and gas setting and Graham and Rogers (2002) in a more general setting).

Conclusions and Suggestions for Future Research

Overall, we find that corporate risk management literature is increasingly reliant on samples drawn from commodity users and producers. The findings of research to date show that commodity price risk can affect the returns on stocks and that commodity hedging can reduce this exposure. Results are mixed regarding whether commodity risk management adds value. Finally, various factors have been shown to affect corporate hedging policy. These factors

include variables related to financing and compensation, as well as selective hedging by firm management.

Despite the fact that empirical work in corporate risk management has been published over the last 20+ years, we observe that academic understanding is still very incomplete. In particular, the academic finance profession is still far from being able to provide clear guidance as to whether Mr. Topping (“hedging is a fiduciary responsibility”) or Mr. Kirby (“hedging is a waste of time”) are more correct in their views. Thus, we believe that there are plenty of opportunities to expand our knowledge in the risk management area. Because of data limitations with respect to studying corporate risk management generally by nonfinancial companies, there should be plenty of opportunities to study risk management through the lens of commodity producers and users.

Below are a few suggestions to researchers interested in exploring these topics.

- More research is needed on the value of hedging input price risk (i.e., cost risk management). To date, all but one study in this area have involved airlines and jet fuel price risk. Food processing companies seem like one natural sample to examine, and there are likely other candidate industries as well.
- What are primary reasons for divergent results (especially regarding the value effect of hedging) between commodity producers and users?¹⁴ Do we, as academics, need to stop trying to generalize findings and recognize these two types of samples as truly different in terms of how we communicate results and how they fit into the

¹⁴ DeAngelis and Ravid (2017) recently provide one clue to the answer to this question. They find results suggesting that market power has a negative relation with hedging by firms in output industries, but has no effect on hedging by firms in input industries. They conclude that input hedging and output hedging are fundamentally different policies in these differing industry settings. An implication of their findings is that researchers should expect different results in input versus output environments.

In an earlier paper, MacKay and Moeller (2007) study oil refiners and the different impact hedging and value has on hedging costs (crude oil) versus revenues (gasoline and heating oil) for a sample of oil refiners. They find hedging revenues and leaving costs exposed can add more to firm value.

literature? Additionally, do we need to perform more replications of previous studies? However, researchers should recognize that replications may entail a significant personal cost because significant amounts of hedging data are hand-collected by the researchers themselves. Thus, there would be a disincentive to be a “first-mover” on hedging research unless researchers could be adequately compensated for subsequent users who utilize their data.

- Are there market situations where positive value is found for hedging by oil and gas companies? The fact that oil and gas firms hedge so frequently makes the finding of negative value effects troubling. Is a time-period bias affecting the findings?
- What role does corporate culture play in commodity hedging? An interesting observation comes from the airline industry. In 2005, during industry consolidations, America West Holdings management (which did not hedge) acquired the assets of US Airways (but retained the US Airways name). Subsequently, in 2013 US Airways merged with American Airlines (with American’s name on the successor company but with US Airways’ management team in charge of the combined firm). Interestingly, both companies stopped hedging post-takeover. Is this change in hedging optimal? How does this type of change in hedging policy that seems to be inherited through corporate takeovers fit with studies of selective hedging?
- Does enterprise risk management influence commodity hedging and are the combined techniques associated with greater firm value?
- From a practitioner perspective, research needs to help businesses make decisions about whether or not to hedge, and if the answer is to hedge, how much. Therefore, hedging research may benefit from more field-based case studies in which

researchers are closely engaged with corporate hedging policy at individual companies. For example, Petersen and Thiagarajan (2000) conduct a non-field-based case study of hedging by two gold mining firms, one an active derivatives hedger while the other did not use derivatives. Brown (2001) conducted a field-based study on a non-identified firm's usage of foreign currency derivatives in 1996. So, there are precedents for case-based research, and these have been published in high-level academic finance journals. However, it has been a long time since this happened. The key issue is that hedging research may benefit from a recognition that there is not prescriptive hedging policy that will fit all businesses.

Broadly, risk management helps firms manage and adapt to change, which is key to long term survival. Perhaps Charles Darwin summarizes it best when observing that mutability is the only permanent feature of the landscape:

“It's not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.” (Charles Darwin, 1809-1882)

References

- Adam, Tim R., 2002, Risk management and the credit risk premium. *Journal of Banking and Finance* 26 (2-3): 243-269.
- Adam, Tim R., 2009, Capital expenditures, financial constraints, and the use of options, *Journal of Financial Economics* 92, 238-251.
- Adam, Tim R., and Chitru S. Fernando, 2006, Hedging, speculation, and shareholder value. *Journal of Financial Economics* 81 (2):283-309.
- Adam, Tim R., Sudipto Dasgupta, and Sheridan Titman, 2007, Financial constraints, competition, and hedging in industry equilibrium. *Journal of Finance* 62, 2445-2473.
- Adam, Tim R. and Chitru S. Fernando, 2008, Can firms use hedging programs to profit from the market? Evidence from Gold Producers,” *Journal of Applied Corporate Finance* 20 (Fall), 86-97.
- Adam, Tim R., Chitru S. Fernando, and Evgenia Golubeva, 2015, Managerial overconfidence and corporate risk management, *Journal of Banking and Finance* 60, 195-208.
- Adam, Tim R., Chitru S. Fernando, and Jesus Salas, 2017, Why do firms engage in selective hedging? Evidence from the gold mining industry, *Journal of Banking and Finance*, 77, 269-282.
- Allayannis, George, and James P. Weston, 2001, The use of foreign currency derivatives and firm market value, *Review of Financial Studies* 14, 243-276.
- Bakke, Tor-Erik, Hamed Mahmudi, Chitru S. Fernando, and Jesus M. Salas, 2016, The causal effect of option pay on corporate risk management, *Journal of Financial Economics* 120, 623-643,
- Bartram, Söhnke M., Gregory W. Brown, and Jennifer Conrad, 2011, The effects of derivatives on firm risk and value, *Journal of Financial and Quantitative Analysis* 46 (4) 967-999.
- Berghöfer, Britta and Brian Lucey, 2014, Fuel hedging, operational hedging and risk exposure – Evidence from the global airline industry, *International Review of Financial Analysis* 34, 124-139.
- Bessembinder, Hendrik, 1991, Forward contracts and firm value: Incentives and contracting effects. *Journal of Financial and Quantitative Analysis* 26, 491-532.
- Bodnar, Gordan M. and M.H.Franco Wong, 2003, Estimating exchange rate exposure: Issues in model structure, *Financial Management* 32, 35-67.

- Breeden, Douglas, and S. “Vish” Viswanathan, 1998, Why do firms hedge? An asymmetric information model, *The Journal of Fixed Income* 25 (3), 7-25.
- Brown, Gregory W., 2001, Managing foreign exchange risk with derivatives, *Journal of Financial Economics* 60, 401-448.
- Brown, Gregory W., Peter R. Crabb, and David Haushalter, 2006, Are firms successful at selective hedging? *Journal of Business* 79, 2925-2949.
- Brown, Gregory W. and Klaus Toft, 2001, How firms should hedge, *Review of Financial Studies* 15 (4), 1283-1324.
- Callahan, Matthew, 2002, To hedge or not to hedge... That is the question: Empirical evidence from the North American gold mining industry 1996-2000, *Financial Markets, Institutions & Instruments* 11, pp. 271-288.
- Campello, Murillo, Chen Lin, Yue Ma, and Hong Zou, 2011, The real and financial implications of corporate hedging, *Journal of Finance* 66, 1615 – 1647.
- Carter, David A., Daniel A. Rogers, and Betty J. Simkins, 2006, Does hedging affect firm value? Evidence from the U.S. airline industry, *Financial Management* 35 (1), 53-86.
- Carter, David A., Daniel A. Rogers, and Betty J. Simkins, 2006, Hedging and value in the U.S. airline industry, *Journal of Applied Corporate Finance* 18, 21-33.
- Carter, David A., Daniel A. Rogers, and Betty J. Simkins, 2013, Does hedging reduce economic exposure? Hurricanes, jet fuel prices, and airlines, *Handbook of Research Methods and Applications in Empirical Finance*, 2013, Editors: Adrian Bell, Chris Brooks and Marcel Prokopczuk, Edward Elgar Publishing Ltd.
- Chidambaran, N.K., Chitru S. Fernando, and Paul A. Spindt, 2001, Credit enhancement through financial engineering: Freeport McMoRan’s gold-denominated depositary shares, *Journal of Financial Economics*, 60, 487-528.
- Coles, Jeffrey, Michael Lemmon, and Felix Meschke, 2012, Structural models and endogeneity in corporate finance: The link between managerial ownership and corporate performance, *Journal of Financial Economics* 103 (1), 149-168.
- Cornaggia, Jess, 2013, Does risk management matter? Evidence from the U.S. agricultural industry, *Journal of Financial Economics* 109, 419-440.
- DeAngelis, David and S. Abraham Ravid, 2017, Input hedging, output hedging, and market power, *Journal of Economics and Management Strategy* 26 (1), 123-151.
- DeMarzo, Peter M. and Darrell Duffie, 1995, Corporate incentives for hedging and hedge accounting, *Review of Financial Studies* 8, 743 – 772.

- Dewally, Michael, Louis H. Ederington, and Chitru S. Fernando, 2013, *Review of Financial Studies* 26 (1), 2648-2683.
- Fehle, Frank, and Sergey Tsyplakov, 2005, Dynamic risk management: Theory and evidence, *Journal of Financial Economics* 78, 3-47.
- Fleten, Stein-Erik, Stein W. Wallace, and William T. Ziemba, Hedging electricity portfolios via stochastic programming, *Decision Making Under Uncertainty: Energy and Power*, Claude Greengard and Andrzej Ruszczyński, Andrzej (Eds.), Publisher: Springer-Verlag Publisher, 71-93.
- Froot, Kenneth, David Scharfstein, and Jeremy Stein, 1993, Risk management: Coordinating investment and financing policies, *Journal of Finance* 48, 1629-1658.
- Gay, Gerry, Nam, J. and Marion Turac, 2003, On the optimal mix of corporate hedging instruments: Linear versus nonlinear derivatives, *Journal of Futures Markets*, 23(3), 217-239.
- Gerner, Mathias and Ehud I. Ronn, 2013, Fine-tuning a corporate hedging portfolio: The case of an airline, *Journal of Applied Corporate Finance* 25 (4), 74-86.
- Gilje, Erik P. and Jerome P. Taillard, 2016, Does hedging affect firm value? Evidence from a natural experiment, University of Pennsylvania working paper.
- Graham, John R. and Daniel A. Rogers, 2002, Do firms hedge in response to tax incentives?, *Journal of Finance* 57, pp. 815-839.
- Guay, W., 1999, The impact of derivatives on firm risk: An empirical examination of new derivative users, *Journal of Accounting and Economics* 26, 319-351.
- Guay, Wayne R. and S.P. Kothari, 2003, How much do firms hedge with derivatives?, *Journal of Financial Economics* 70, 423-461.
- Haushalter, David, 2000, Financing policy, basis risk, and corporate hedging: Evidence from oil and gas producers, *The Journal of Finance* 55 (1), 107-152.
- Haushalter, David, Sandy Klasa, and William F. Maxwell, 2007, The influence of product market dynamics on a firm's cash holdings and hedging behaviour, *Journal of Financial Economics* 84 (3), 797-825.
- Hentschel, Ludger, and S.P. Kothari, 2001, Are corporations reducing or taking risks with derivatives? *Journal of Financial and Quantitative Analysis* 36 (1), 93-118.
- Jin, Yanbo, and Philippe Jorion, 2006, Firm value and hedging: Evidence from U.S. oil and gas producers. *Journal of Finance* 61 (2), 893-919.

- Kumar, Praveen and Ramon Rabinovitch, 2013, CEO entrenchment and corporate hedging: Evidence from the oil and gas industry, *Journal of Financial and Quantitative Analysis* 48 (3), 887-917.
- Leland, Hayne E., 1998, Agency costs, risk management, and capital structure, *Journal of Finance* 53, 1213-1243.
- Lin, Rueyjiaw and Yuanchen Chang, 2009, Does hedging add value: Evidence from the global airline industry, *SSRN Working Paper*.
- Lookman, Alex, 2004, Does hedging increase firm value? Evidence from oil and gas producing firms, Unpublished working paper, Carnegie Mellon University.
- MacKay, Peter, and Sara B. Moeller, 2007, The value of corporate risk management, *Journal of Finance* 62 (3), 1379-1419.
- Mello, Antonio S., and Martin Ruckes, 2005, Financial hedging and product market rivalry, Unpublished working paper.
- Nain, Amrita, 2004, The strategic motives for corporate risk management, Unpublished working paper, University of Michigan.
- Nance, Deana R., Clifford W. Smith, Jr., and Charles W. Smithson, 1993, On the determinants of corporate hedging, *Journal of Finance* 48 (1), 267-284.
- Pérez-González, Francisco and Hayong Yun, 2013, Risk management and firm value: Evidence from weather derivatives, *Journal of Finance*, 68 (5), 2143-2176.
- Petersen, Mitchell A., and S. Ramu Thiagarajan, 2000, Risk measurement and hedging: With and without derivatives, *Financial Management* 29 (4), 5-29.
- Popova, Ivilina and Betty J. Simkins. 2015, OTC vs. exchange traded derivatives and their impact on hedging effectiveness and corporate capital requirements, *Journal of Applied Corporate Finance* 27 (1), 63-70.
- Rampini, Adriano A. and S. Viswanathan, 2010, Collateral, risk management, and the distribution of debt capacity, *Journal of Finance* 65 (6), 2293-2322.
- Rampini, Adriano A. and S. Viswanathan, 2013, Collateral and capital structure, *Journal of Financial Economics* 1091, 466-492.
- Rampini, Adriano A., Amir Sufi, and S. Viswanathan, 2014, Dynamic risk management, *Journal of Financial Economics* 111, 271-296.

- Smith, Clifford W., and René M. Stulz, 1985, The determinants of firms' hedging policies, *Journal of Financial and Quantitative Analysis* 20, 391-405.
- Stulz, René M., 1984, Optimal hedging policies, *Journal of Financial and Quantitative Analysis* 19 (2), 127-140.
- Smithson, Charles, and Betty J. Simkins, 2005, Does risk management add value? A survey of the evidence, *Journal of Applied Corporate Finance* 17, 8-17.
- Stulz, René, 1996, Rethinking risk management, *Journal of Applied Corporate Finance* 9, 8-24.
- Tomek, William G. and Hikaru H. Peterson, Risk management in agricultural markets: A review, *Journal of Futures Markets* 21 (10), 953-985.
- Treanor, Stephen D., Daniel A. Rogers, David A. Carter and Betty J. Simkins, 2014, Exposure, hedging, and value: New evidence from the U.S. airline industry *International Review of Financial Analysis* 34, 200-211.
- Treanor, Stephen D., Betty J. Simkins, Daniel A. Rogers, and David A. Carter, 2014, Does operational and financial hedging reduce exposure? Evidence from the U.S. airline industry *Financial Review* 49 (1), 149-172.
- Tufano, Peter, 1996, Who manages risk? An empirical examination of risk management practices in the gold mining industry, *Journal of Finance* 51 (4), 1097-1137.
- Tufano, Peter, 1998a, The determinants of stock price exposure: Financial engineering and the gold mining industry, *Journal of Finance* 53, 1015-1052.
- Tufano, Peter, 1998b, The agency costs of corporate risk management, *Financial Management* 27 (1), 67-77.

Figure 1: Structure of the Literature on Commodity Risk Management

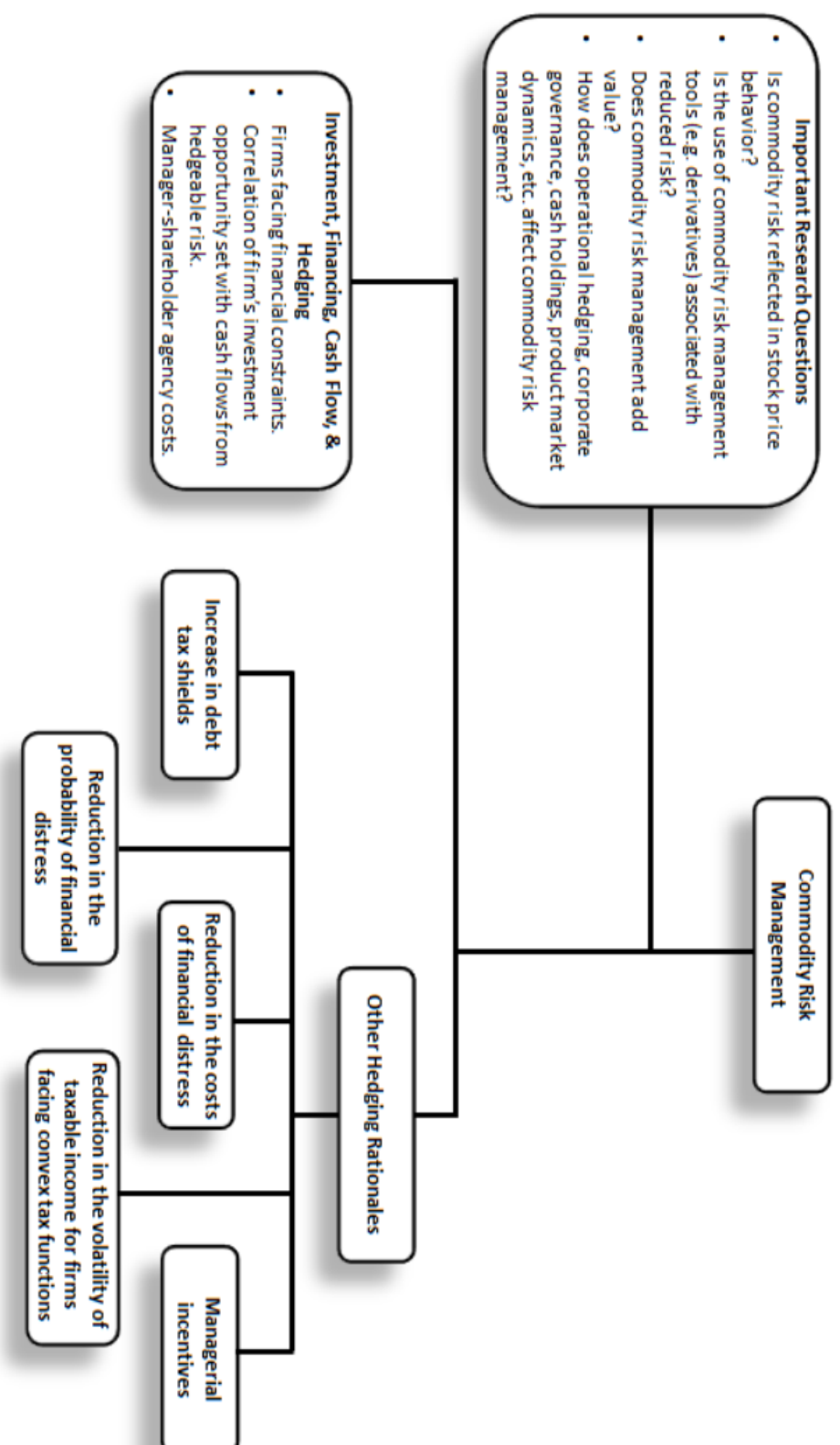


Table 1: Theoretical Papers on Risk Management by Firms

This table summarizes some of the leading theoretical papers on risk management by firms including what was examined and the theoretical findings. The citations provided in the “Findings” column are based on Google Scholar citations as of August 20, 2017.

Journal	Date	Authors	What was examined?	Findings
Journal of Financial and Quantitative Analysis	1984	Stulz	Optimal hedging policies in an intertemporal setting	Firms follow an active hedging policy; Derives optimal hedging policies for risk-averse agents in the presence of uncertainty about future prices and hedging holding costs. Citations: 1029
Journal of Financial and Quantitative Analysis	1985	Smith and Stulz	Effect of hedging on firm value due to tax function convexity and bankruptcy costs; Effect of managerial risk aversion, compensation form, and hedging	Hedging increases firm value more as tax function convexity increases; Hedging increases firm value to the degree that it is able to reduce bankruptcy probability; Option-like compensation reduces managerial incentive to hedge. Citations: 3169
Journal of Financial and Quantitative Analysis	1991	Bessembinder	How risk hedging can increase firm value	Risk hedging increases firm value by reducing incentives to underinvest and allows firm to commit to meet obligations. Citations: 455
Journal of Finance	1993	Froot, Scharfstein, and Stein	A new frame for analyzing corporate risk management policies	When external finance is more costly than internal funds, firms will hedge. Optimal hedging strategy does not involve complete insulation of firm value from marketable sources of risk. Citations: 3027
Review of Financial Studies	1995	DeMarzo and Duffie	Information effect of financial risk management	Financial hedging improves the informativeness of corporate earnings as a signal of management ability and project quality by eliminating extraneous noise. Citations: 752
Journal of Finance	1998	Leland	Effect of agency costs on joint determination of leverage and risk management	Corporate risk management allows firms to increase their optimal debt capacity. Citations: 1555
Journal of Fixed Income	1998	Breeden and Viswanathan	Incentive of managers to hedge in an asymmetric information model	Hedging is an attempt to improve the informativeness of learning process by higher managers. Citations: 297
Journal of Banking and Finance	2002	Adam	How the credit risk premium affects firms' optimal hedging strategies for gold mining firms.	The model predicts that if the credit risk premium is relatively small (large), firms use convex (concave) hedging strategies. Firms in between use both, e.g. collar strategies. Model replicates

				observations for industry. Citations: 56
The Review of Financial Studies	2002	Brown and Toft	The strategy of hedging under the assumption that firms can experience costly states of nature and derive optimal hedging strategies using vanilla derivatives	Customized exotic derivatives are better than vanilla contracts when correlations between prices and quantities are large in magnitude and when quantity risks are greater than price risks. Citations: 218
Journal of Futures Market	2003	Gay, Nam, and Turac	Strategy of choosing optimal mix of linear and non-linear derivatives	Linear instruments will dominate a firm's hedging mix but that this usage of linear products will decline the greater a firm's quantity risk and the greater the price risk related to their output. Citations: 27
Working paper	2005	Mello and Ruckes	Optimal hedging and production strategies of financially constrained firms in imperfect competitive markets	Oligopolistic firms hedge the least when they face intense competition and firms' financial condition is similar. Citations: 27
Journal of Finance	2007	Adam, Dasgupta, and Titman	Hedging decisions of firms depending on the hedging choices of competitors (1997-1999)	Industries with more competition, more elastic demand, and less convexity in production costs has more heterogeneity in hedging choices, and more companies will choose to hedge in an industry that are subject to tighter financial constraints and with larger market. Citations: 139
Journal of Finance	2010	Rampini and Viswanathan	Relation between risk management and financial constraints	Find important connection between firm financing and risk management in a finite horizon model (primarily a model with two periods). Citations: 216
Journal of Financial Economics	2013	Rampini and Viswanathan	Relation between investment, capital structure, leasing and risk management	Generalizes 2010 paper to an infinite horizon setting. More constrained firms hedge less and lease more, in addition to other findings. Citations: 194
Journal of Financial Economics	2014	Rampini, Sufi, and Viswanathan	Trade-off of need for collateral between debt and hedging contracts. Builds on above 2010 and 2013 papers by Rampini and Viswanathan.	Binding financial constraints force firms to collateralize debt agreements and thus risk management becomes less utilized as less collateral is available to back hedging contracts. Evidence that constrained airlines hedge less. Citations: 101

Table 2: Empirical Examination of Impact of Commodity Price Risk Management by Users of Commodities

This table lists the leading empirical papers investigating commodity risk management by nonfinancial firms that are users of commodities. The table very briefly describes what was examined and the key findings. The citations provided in the “Findings” column are based on Google Scholar citations as of August 20, 2017.

Journal	Date	Author(s)	What was examined? (Time Period)	Findings
Financial Management	2006	Carter, Rogers, and Simkins	Impact of fuel hedging on firm value for 26 U.S. airlines (1994-2000)	Positive relation between use of fuel price risk derivatives and firm value (Tobin's Q) Citations: 307
Journal of Finance	2007	MacKay and Moeller	Examine effect on firm value of hedging concave product revenues and convex input costs for 34 oil refiners (1985 – 2004)	Value of hedging revenues adds to operating cash flow while leaving input costs unhedged is more valuable. Citations: 195
Working paper	2009	Lin and Chang	Whether jet fuel hedging increases the market value of airline companies around the world (1995-2005)	Jet fuel hedging is positively related to market value. The risk-taking behavior of executives and the tendency to avoid financial distress are important determinants for the jet fuel hedging activities. Citations: 12
International Review of Financial Analysis	2014	Berghöfer and Lucey	Financial and operational hedging impact on risk exposure for 64 global airlines (2002-2012)	Financial hedging does not reduce exposure to fuel prices. Similar results for operational hedging. Fleet diversity related to risk exposure. Citations: 16
International Review of Financial Analysis	2014	Treanor, Rogers, Carter, and Simkins	Impact of hedging under different price regimes for 27 U.S. airlines (1994-2008)	Find that airline exposures to fuel prices are higher when fuel prices are high or when they are rising. In response to higher fuel price levels, rising fuel prices, and higher levels of exposure to fuel prices, airlines tend to increase their hedging activity. They find a positive hedging premium. Citations: 8
Financial Review	2014	Treanor, Simkins, Rogers, and Carter	Impact of financial and operational hedging on fuel exposure for 27 U.S. airlines (1994-2008)	Financial and operational hedging are important risk management tools in reducing exposure to fuel prices. Operational hedging is found to be more economically important. Citations: 19
Journal of Financial Economics	2014	Rampini, Sufi, and Viswanathan	Dynamic risk management based on the trade-off between financing and fuel risk management practices for 23 airlines (1996-2009)	Evidence that constrained airlines hedge less. As airlines approach distress and become constrained for collateral, hedging declines. Support for their dynamic theory of risk management. Citations: 101

Table 3: Empirical Examination of Impact of Commodity Price Risk Management by Producers of Commodities

This table lists the leading empirical papers investigating commodity risk management by nonfinancial firms that are producers of commodities. The table very briefly describes what was examined and the key findings. The citations provided in the “Findings” column are based on Google Scholar citations as of August 20, 2017.

Journal	Date	Author(s)	What was examined? (Time Period)	Findings
Journal of Finance	1996	Tufano	Risk management in the gold mining industry. (1990 – 1993)	Firms whose managers hold more options manage less gold price risk, and firms whose managers hold more stock manage more gold price risk. Risk management is negatively associated with the tenure of firms' CFOs. Citations: 1476
Journal of Finance	1998	Tufano	Determinants of exposure of gold mining firms to changes in the price of gold.(1990-1994)	Gold firm exposures are negatively related to the firm's hedging and diversification activities and to gold prices and gold return volatility. Citations: 270
Journal of Finance	2000	Haushalter	Hedging policies of oil and gas producers (1992-1994)	The extent of hedging is related to financing costs. Companies with greater financial leverage manage price risks more extensively. Citations: 698
Financial Management	2000	Petersen and Thiagarajan	Difference in risk management strategies between two gold mining firms (1976-1994)	Difference in opportunities and incentives for risk reduction explain part of the difference in risk management strategies. Citations: 249
Journal of Financial Economics	2001	Chidambaran, Fernando, and Spindt	Combination of hedging and financing for gold-mining firm, Freeport McMoRan (1993-1994)	Bundling hedging with financing, financial engineering, can enhance firm value. Citations:33
Financial Markets, Institutions & Instruments	2002	Callahan	Impact of gold hedging on 20 North American gold mining firms (1996-2000)	Negative correlation between extent of gold hedging and performance of the firm stock price. Citations: 36
Unpublished Working Paper	2004	Lookman	Exploration and production (E&P) firms that hedge commodity price risk. Unbalanced panel set of 125 firms (364 firm-year observations)	Hedging is associated with lower firm value for undiversified E&P firms, and higher firm value for diversified E&P firms. In aggregate, no association with hedging and firm value is detected. Citations: 43
Journal of Financial Economics	2005	Fehle and Tsyplakov	Tests their own model of hedging maturity choice on a sample of gold mining firms (1993-1999).	The structure of transaction costs can have an important effect on the firm's risk management strategy. Firms that are either far from financial distress or deep in financial distress neither initiate nor adjust their risk management

				instruments. Citations: 70
Journal of Finance	2006	Jin and Jorion	Risk management activities of 119 U.S. oil and gas producers (1998-2001)	Hedging reduces the firm's stock price sensitivity to oil and gas prices and hedging is not related to firm value (Tobin's Q). Citations: 520
Journal of Financial Economics	2006	Adam and Fernando	Cash gains of gold mining firms from derivatives transactions and its effect on market value (1989-1999)	Gold mining firms realized cash flow gains from hedging, and it has increased shareholder value, which conflicts with the assumption that derivatives transactions have zero net present value. Citations: 236
Journal of Business	2006	Brown, Crabb, and Haushalter	44 gold mining firms (1993-1998)	Influence of managers' views on risk management and their attempts to time commodity markets with their risk management policy decisions (selective hedging). Managers can generate significant gross profits from varying their hedge ratios, but the magnitude of these gains are small. No evidence that selective hedging improves financial performance. Citations: 219
Journal of Finance	2007	MacKay and Moeller	Examine effect on firm value of hedging concave product revenues and convex input costs for 34 oil refiners (1985 – 2004)	Value of hedging revenues adds to operating cash flow while leaving input costs unhedged is more valuable. Citations: 195
Journal of Financial Economics	2009	Adam	Examine effect of financial constraints and investment metrics on decision to use options by gold mining firms (1989 – 1999)	Insurance strategies are more typically used by less-constrained firms, while more-constrained firms are more likely to engage in collar strategies. Firms with larger investment programs are more likely to employ insurance strategies. Citations: 54
Journal of Financial and Quantitative Analysis	2013	Kumar and Rabinovitch	Effect of CEO entrenchment and free cash flow agency problems on hedging by 41 oil and gas producers (1996-2008)	Hedging intensity is positively related to factors that amplify entrenchment and free cash flow agency costs. Hedging is motivated by reduction of financial distress and borrowing costs and influenced by both intrinsic cash flow risk and temporary spikes in commodity price volatility. Citations: 38
Journal of Banking and Finance	2015	Adam, Fernando, and Golubeva	Gold mining firms managerial overconfidence in the discrepancies between theory and practice of risk management (1989-1999)	Managers increase speculative activities following speculative cash flow gains, but do not reduce speculative activities following speculative loss. Citations: 24
Journal of Financial Economics	2016	Bakke, Mahmudi, Fernando, and	Casual effect of option pay on risk management by oil and gas producers (2003-	Firms that did not expense options prior to passage of FAS 123R significantly reduced option pay and increased

		Salas	2006)	hedging intensity compared to firms that did not use options or expensed them prior to the passage of the standard. Citations: 25
Journal of Banking and Finance	2017	Adam, Fernando, and Salas	Speculation with hedging programs by gold mining firms (1989-1999)	Selective hedging is more prevalent among financially constrained firms. Citations: 16

Accepted manuscript

Table 4: Empirical Examination of Impact of Commodity Price Risk Management by Firms (not able to classify by Users or Producers)

This table lists the leading empirical papers investigating commodity risk management by nonfinancial firms where it is not possible to classify as a user or producer of commodities. The table very briefly describes what was examined and the key findings. The citations provided in the “Findings” column are based on Google Scholar citations as of August 20, 2017.

Journal	Date	Author(s)	What was examined? (Time Period)	Findings
Journal of Finance	1993	Nance, Smith, and Smithson	Hypothesis that hedging increases firm value by reducing expected taxes, expected costs of financial distress, or other agency costs (1986)	Firms which hedge face more convex tax functions, have less coverage of fixed claims, have more growth options in investment opportunity set. Citations: 1426
Journal of Accounting and Economics	1999	Guay	Derivatives' roles in firms initiating derivatives use (1990-1994)	Firms use derivatives to hedge risk, not to increase entity risk. Realized risk reductions and decisions to initiate derivatives programs vary across firms with the expected benefits from hedging. Citations: 440
Journal of Financial and Quantitative Analysis	2001	Hentschel and Kothari	If firms systematically reduce or increase riskiness with derivatives (1990-1993)	Many firms manage their exposures with large derivatives positions. Compared to firms that do not use financial derivatives, firms that use derivatives display few measurable differences in risk. Citations: 387
Journal of Finance	2002	Graham and Rogers	Effect of tax incentives on the extent of corporate hedging with derivatives (1994-1995)	Firms hedge to increase debt capacity and due to expected financial distress costs and firm size. Citations: 789
Journal of Financial Economics	2003	Guay and Kothari	The magnitude of hedging used by non-financial corporations (1995-1997)	Corporate derivatives use accounts for a small portion of non-financial firm's overall risk profile, which questions the importance of firms' derivative use suggested by previous research. Citations: 622
Journal of Finance	2007	Adam, Dasgupta, and Titman	Hedging decisions of firms depending on the hedging choices of competitors (1997-1999)	Industries with more competition, more elastic demand, and less convexity in production costs has more heterogeneity in hedging choices, and more companies will choose to hedge in an industry that are subject to tighter financial constraints and with larger market. Citations: 139
Journal of Financial Economics	2007	Haushalter, Klasa, and Maxwell	Management of predation risk (1993-2001)	The extent of the interdependence of a firm's investment opportunities with rivals is positively associated with its use of derivatives and the size of its cash holdings.

				Citations: 331
Journal of Finance	2011	Campello, Lin, Ma, and Zou	Impact of hedging for corporate financing and investment (1996-2002)	Hedging can lower the odds of negative realizations, thereby reducing the expected costs of financial distress. Citations: 1182
Journal of Financial and Quantitative Analysis	2011	Bartram, Brown, and Conrad	Effect of derivative use on firm risk and value (2000-2001)	The use of financial derivatives reduces total and systematic risks. Using derivatives is associated with higher value, abnormal returns, and larger profits during the economic downturn in 2001-2002. Citations: 248
Journal of Finance	2013	Pérez-González and Yun	Effect of weather derivatives use on firm risk and value (1960-2007)	The use of weather derivatives leads to higher value, investments, and leverage for electric and gas utilities. Citations: 101
Journal of Economics and Management Strategy	2017	DeAngelis and Ravid	Study the effect of market power on the incidence of commodity hedging in input versus output industries using S&P 500 firms (2001-2005)	Firms in output industries hedge less as market power increases. Commodity hedging by input industry firms is unrelated to market power of these firms. Citations: 2

Accepted manuscript

Table 5: Classification of User and Producer Research by Questions Addressed

This table summarizes which empirical studies examined the following four research questions, and also classifies each study according to which type of hedging (producer or user) and the industry.

Question 1: Is commodity risk reflected in share price behavior?

Question 2: Is the use of commodity risk management tools (derivatives) associated with reduced risk?

Question 3: Is there a relationship between the use of commodity risk management and the value of the firm?

Question 4: Are there other factors that impact a firm's decision to manage commodity price risk?

<u>Questions addressed</u>	<u>Authors</u>	<u>Journal</u>	<u>Year</u>	<u>Hedger type</u>	<u>Industry</u>
Q1	Tufano	JF	1998	Producer	Gold
Q1	Callahan	FMII	2002	Producer	Gold
Q1	Jin and Jorion	JF	2006	Producer	Oil & Gas
Q1	Berghofer and Lucey	IRFA	2004	User	Airline
Q1	Treanor, Simkins, Rogers, and Carter	FR	2004	User	Airline
Q1	Treanor, Rogers, Carter, and Simkins	IRFA	2004	User	Airline
Q2	Tufano	JF	1998	Producer	Gold
Q2	Callahan	FMII	2002	Producer	Gold
Q2	Jin and Jorion	JF	2006	Producer	Oil & Gas
Q2	Berghofer and Lucey	IRFA	2004	User	Airline
Q2	Treanor, Simkins, Rogers, and Carter	FR	2004	User	Airline
Q2	Treanor, Rogers, Carter, and Simkins	IRFA	2004	User	Airline
Q2	Prokopczuk and Zimmerman	working paper	2005	Producer	Multiple
Q3	Chidambaran, Fernando, and Spindt	JFE	2001	Producer	Gold
Q3	Adam	JBF	2001	Producer	Gold

			2		
		working paper	200		Oil & Gas
Q3	Lookman	working paper	4	Producer	Gas
			200		
Q3	Carter, Rogers, and Simkins	FM	6	User	Airline
			200		Oil & Gas
Q3	Jin and Jorion	JF	6	Producer	Gas
			200		
Q3	Adam and Fernando	JFE	6	Producer	Gold
			200		
Q3	Brown, Crabb, and Haushalter	JB	6	Producer	Gold
			200	Producer &	Oil refining
Q3	MacKay and Moeller	JF	7	User	
		working paper	200		
Q3	Lin and Chang	working paper	9	User	Airline
	Treanor, Rogers, Carter, and Simkins		201		
Q3	Simkins	IRFA	4	User	Airline
		working paper	201		Oil & Gas
Q3	Gilje and Taillard	working paper	6	Producer	Gas
			199		
Q4	Tufano	JF	6	Producer	Gold
			200		Oil & Gas
Q4	Haushalter	JF	0	Producer	Gas
			200		
Q4	Carter, Rogers, and Simkins	FM	6	User	Airline
			200		
Q4	Brown, Crabb, and Haushalter	JB	6	Producer	Gold
		working paper	200		
Q4	Lin and Chang	working paper	9	User	Airline
			200		
Q4	Adam	JFE	9	Producer	Gold
			201		Oil & Gas
Q4	Kumar and Rabinovitch	JFQA	3	Producer	Gas
	Rampini, Sufi, and Viswanathan		201		
Q4	Viswanathan	JFE	4	User	Airline
	Adam, Fernando, and Golubeva		201		
Q4	Golubeva	JBF	5	Producer	Gold
	Bakke, Mahmudi, Fernando, and Salas		201		Oil & Gas
Q4	and Salas	JFE	6	Producer	Gas
			201		
Q4	Adam, Fernando, and Salas	JBF	7	Producer	Gold

Table 6: The Eight Most Influential Papers in Commodity Risk Management based on Citations

This table lists the eight most highly cited papers in commodity risk management. The citations listed are based on Google Scholar citations as of August 20, 2017. The citations per year are the average since the year of publication.

Journal	Date	Author(s)	Title	Total Citations	Citations per Year
Journal of Finance	1996	Tufano	Who manages risk? An empirical examination of risk management practices in the gold mining industry	1476	70.3
Journal of Finance	1998	Tufano	The determinants of stock price exposure: Financial engineering and the gold mining industry	270	14.2
Journal of Finance	2000	Haushalter	Financing policy, basis risk, and corporate hedging: Evidence from oil and gas producers	698	41.1
Financial Management	2006	Carter, Rogers, and Simkins	Does hedging affect firm value? Evidence from the U.S. airline industry	307	27.9
Journal of Finance	2006	Jin and Jorion	Firm value and hedging: Evidence from U.S. oil and gas producers	520	47.3
Journal of Financial Economics	2006	Adam and Fernando	Hedging, speculation, and shareholder value	236	21.4
Journal of Business	2006	Brown, Crabb, and Haushalter	Are firms successful at selective hedging?	219	19.9
Journal of Financial Economics	2014	Rampini, Sufi, and Viswanathan	Dynamic risk management	101	33.7