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How Do Financial Firms Manage Risk? Unraveling the Interaction of Financial and Operational Hedging

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This paper investigates how firms manage risk by examining the relationship between financial and operational hedging using a sample of bank holding companies. Risk management theory holds that capital market imperfections make cash flow volatility costly. I investigate whether financial firms consider this cost or focus exclusively on managing tradable exposures. After documenting that acquisitions provide operational hedging by reducing potentially costly volatility, I find that postacquisition financial hedging declines even after controlling for the specific underlying risks. In addition, the decrease in financial hedging is related to the acquisition's level of operational hedging. Larger increases in operational hedging are followed by larger declines in financial hedging. These results indicate that firms in this sample manage aggregate risk, not just tradable exposures, and that operational hedging can substitute for financial hedging.

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1. Introduction

This study is motivated by the widespread challenge of risk management—a challenge highlighted for both financial and nonfinancial firms during the 2008 credit crisis. Both theoretical and empirical research find that cash flow volatility is costly because of capital market imperfections. How firms respond to these costs and manage risk is less clear. While a substantial number of firms uses derivatives to hedge uncertainty, the economic magnitude of this activity appears to be small (Guay and Kothari 2003). Moreover, some evidence exists that firms hedge specific transactions (Brown 2001), even though theory suggests firms should manage aggregate risk (Smith and Stulz 1985, Froot et al. 1993). In addition to financial derivatives, operational decisions can contribute to risk management goals. Managers can reduce cash flow volatility by diversifying cash flows through project selection, acquisitions, or investments in flexibility. However, the evidence on how to coordinate these decisions with derivatives use is limited (Babich and Sobel 2004, Ding et al. 2007).

This paper investigates how firms manage risk by examining the impact of operational decisions for a sample of bank holding companies (BHCs). If firms manage total volatility and not just specific transaction risks, then such corporate decisions should be integral to other risk management choices. In fact, firms may regard such operational hedging as a substitute for financial hedging. Although substituting risk management choices is consistent with the existing theory that firms manage aggregate risk, the empirical evidence is quite mixed. After introducing two improvements to the identification strategy commonly applied to hedging research, I present evidence showing that financial firms manage the costs of volatility, not just risks arising from specific transactions. Further, this paper contributes to the risk management literature by documenting a direct substitution of operational hedging for financial hedging. These results are important because they provide new insight into firm risk management practices and emphasize the interdependence of derivatives use and broader corporate decisions.

This research is most relevant to firms where risk management is more advantageous. In the world of Modigliani and Miller, risk management is not a tool for value creation. This changes when cash flow volatility is costly because of capital market imperfections associated with financial distress, tax convexity, and external financing (Tufano 1996, Minton and Schrand 1999). Because this paper finds evidence that derivatives use and operational decisions are substitutes for financial firms, limiting redundant activities can reduce costs and/or provide a competitive advantage. To the extent these results extend to other industries, firms with higher distress costs (such as those where reputation or human capital are important) or larger financing costs (such as high growth or more opaque industries) will benefit most from risk

management and therefore should focus on coordinating operational and financial hedging to maximize the gains from risk management expenditures. For example, banks face higher distress costs than the average nonfinancial firm (Delong 2003) and bank regulators advocate loan diversification in addition to derivatives use (Laeven and Levine 2009).

To isolate the relationship between financial and operational hedging, this paper differs from the existing literature in two important regards. First, reduced cash flow volatility is the primary definition of operational hedging. This definition avoids the use of categorical proxies for diversifying cash flows, such as the number of business segments or degree of geographic diversification, that are found frequently in the finance literature. Nor does it include all investments in flexibility, a common definition of operational hedging used in the operations literature. Van Mieghem (2003, p. 296) states that, "mitigating risk or hedging involves taking counterbalancing actions so that the future value varies less over the possible states of nature." However, some of these diversification or flexibility decisions actually could increase cash flow volatility (Berger et al. 1999, Bish et al. 2005, Chod et al. 2007), requiring additional risk management to reduce the likelihood of distress. Therefore, in this paper, I focus on directly measuring changes in volatility. Second, the empirical analysis in this paper controls for the change in a firm's underlying risk exposure. Smith and Stulz (1985) note that without the underlying exposure it would be impossible to attribute financial hedging adjustments to increased operational hedging as opposed to changes in the underlying tradable risk. Did derivatives use change because overseas expansion provided operational hedging or because there is new currency risk? Controlling for the exposure isolates the impact of volatility changes on derivatives use.

Operational decisions may reduce both specific tradable exposures as well as potentially costly volatility. Although financial hedging is expected to vary with the level of tradable risk, this is the first research to test whether managers recognize a tradeoff between lowering volatility and hedging with derivatives. If risk management focuses exclusively on specific exposures that can be mitigated with derivatives, then cash flow volatility unrelated to these exposures is irrelevant. However, if the theory literature is correct and firms manage aggregate volatility to minimize the costs of distress or external financing, then decisions that reduce volatility will result in less financial hedging even if the tradable exposures are constant.

Significant shifts in operational risks, such as those that can arise through merger and acquisition (M&A) activity, provide the most direct means of observing risk management decisions. On the most basic level, combining firms will reduce cash flow volatility to the extent that the two original entities' cash flows are not perfectly correlated (Lewellen 1971). Both academics (Stulz 1990, Aggarwal and Samwick 2003, Van Mieghem 2007) and numerous managers argue that diversifying idiosyncratic risk is a key motivation and/or benefit for M&A activity. For example, the JPMorgan Chase and Bank One merger proposal cited volatility reduction as a specific motive for the deal (emphasis added):

> [B]alance between retail and institutional financial services *will reduce the volatility of the combined company's earnings compared to JPMorgan Chase on its own*. (SEC Edgar Database, p. 38)

Likewise, the Bank of New York and Mellon Financial merger proposal stated:

> [T]he combined company will have a more balanced business mix, which will tend to reduce volatility in the operating results of the combined company. (SEC Edgar Database, p. 43)

And this behavior is not limited to financial firms. When Canadian firm Harvest Energy, an active derivatives user, acquired North Atlantic Refinery in 2006, managing volatility was emphasized to investors as a primary benefit of the transaction:

> Improved Cash Flow Characteristics—Provides improved future cash flow stability. (Harvest Energy 2006, p. 1)

M&A activity can impact many sources of risk, including price and demand uncertainty. For example, Huchzermeier and Cohen (1996) show that international expansion can provide sourcing flexibility, mitigating price uncertainty. However, international expansion could expose another firm to new markets that experience economic shocks at different times, lowering demand uncertainty. With banks, Hughes et al. (1996) note that diversification through M&A activity can reduce the variance of the loan portfolio and deposit levels. This lessens the impact of any local economic shock but could also improve the capacity and demand match between deposit flows and loan requests. In this paper, I do not assert that risk management is the primary motivation for all M&A activity. Rather, I use M&A activity to examine whether firms adjust their financial hedging in response to changed cash flow volatility.

The questions addressed in this study are relevant across industries, but the necessary firm-level data are not easily obtained (if they can be obtained at all) for nonfinancial firms. BHCs, which are the focus of this study, are the exception. No other industry offers such clear insight into firm behavior. BHCs are required to file detailed quarterly reports on their derivatives

trading and hedging activities. BHCs also report their primary underlying risk exposure and interest rate sensitivity. Using a large sample of BHCs, I examine how hedging with interest rate derivatives changes following acquisitions, controlling for the change in interest rate exposure. I concentrate on interest rate hedging because such contracts constitute the overwhelming majority (97%) of BHC derivatives hedging. The empirical results support the hypotheses that firms manage total volatility and that operational and financial hedging are substitutes. I show that financial hedging decreases after acquisitions and the magnitude of the decrease is related to the amount of operational hedging created. Those acquisitions offering the most operational hedging lead to the largest reductions in hedging with derivatives.

The remainder of this paper is organized as follows. Section 2 introduces the hypotheses and reviews the existing literature. Section 3 presents the data. Section 4 discusses the empirical analysis and results. Section 5 concludes.

2. Interaction of Operational and Financial Hedging

Numerous theoretical papers recognize that hedging extends beyond derivatives use. Huchzermeier and Cohen (1996) note that operational hedging can provide a long term hedge for exchange rate exposure, whereas Froot and Stein (1998) state that firms adjust risk though their leverage and investment choices. Some authors specifically note the risk management benefits of acquisitions. Hirshleifer (1988) asserts that vertical integration is a substitute for financial hedging, Stulz (1990) states that costless acquisitions that reduce cash flow volatility would benefit shareholders, and Gupta and Gerchak (2002) note that mergers can provide operational flexibility.

Based on this literature, I investigate the interaction of operational and financial hedging, developing three empirically testable hypotheses concerning risk management practices.

Hypothesis 1. *Acquisitions can provide operational hedging*.

The academic literature has recognized the potential risk management benefits of M&A activity since Lewellen (1971). Amihud and Lev (1981) find managerial risk aversion is a significant determinant of acquisition activity.[1] In addition, the *Wall Street Journal* often highlights an acquisition's effect on risk exposures and cash flow volatility (*Wall Street Journal* 2004, Samor 2004).

I empirically test the view that acquisitions contribute to risk management. In the context of Smith and Stulz (1985) and Van Mieghem (2007), an acquisition is an operational hedge if it limits potentially costly volatility. Therefore, I directly measure the amount of operational hedging by estimating an acquisition's impact on the acquirer's volatility and avoid using categorical proxies. Because acquisitions may alter the underlying asset exposure, I also examine the level of tradable risk and control for any changes.

Hypothesis 2. *Firms manage aggregate risk, not just transactional exposures*.

Integrated risk management is an increasingly important concept in the risk management literature. Nocco and Stulz (2006) discuss the benefits of addressing aggregate risk in a coordinated manner; Rosenberg and Schuermann (2006) show how to combine credit, market, and operational risk in a joint risk distribution; and Stiroh and Rumble (2006) explain the importance of total risk for financial institutions. These papers build on the work of Froot et al. (1993) and other theoretical papers that assert that hedging adds value by minimizing the costs of total cash flow volatility.

In this integrated framework, optimal risk management does not focus on specific transactional exposures but instead manages total volatility. However, existing empirical work of Mian (1996) and Brown (2001) contradicts the theoretical expectation, and there is little existing evidence for the notion that firms manage aggregate risk. Schrand and Unal (1998) provide some support but find that reallocating risk is an alternative to reducing volatility. I posit that the best way to test if firms manage aggregate risk is to measure their response to an operational hedging shock. Hypothesis 1 states that acquisitions can provide operational hedging. Firms engaging in integrating risk management would consider this jointly with other risk management choices.

I evaluate an acquisition's impact on derivatives use. If the average acquisition reduces cash flow volatility and firms manage aggregate risk, then financial hedging should decline after an acquisition. For example, assume a BHC financially hedges a certain percentage of its interest rate exposure with the goal of limiting costly cash flow volatility. After an operational hedge acquisition, a smaller percentage of its exposure must be financially hedged to maintain the same level of volatility. Alternatively, if firms only manage specific transaction exposures, then changes in aggregate risk are irrelevant for derivatives

[1] The empirical results of this paper, however, are not consistent with the agency motivation of Amihud and Lev (1981). I document a decline in derivatives use after an increase in operational hedging. Risk aversion would lead the manager to seek an overall decrease in volatility and not substitute operational hedging for financial hedging.

use. Under this alternative transaction-based theory, financial hedging should remain constant after controlling for the level of tradable exposure. Thus, a measure of the sensitivity to underlying risk is necessary to evaluate the practice of integrated risk management.

Hypothesis 3. *Operational hedging and financial hedging are substitutes*.

Optimal risk management must take into account the costs of hedging (Smith and Stulz 1985, Van Mieghem 2007). Clearly, acquisitions are a relatively expensive form of risk management, and they may occur for reasons unrelated to hedging, such as empire-building or other synergies. Although the cost of operational hedging can be thought of as the cost difference between two possible acquisitions that meet other management goals where only one contributes to operational hedging, this paper does not attempt to examine the value of such a choice. The focus is on whether acquisitions reduce potentially costly volatility—not on the motivation for the acquisition. If Hypothesis 3 is valid, any increased use of operational hedging should result in an offsetting decline in financial hedging for a firm in equilibrium. That is, operational decisions that reduce nontradable risk will impact the use of derivatives for hedging.

The prior evidence on whether operational and financial hedging are substitutes is ambiguous. Operational and financial hedging are found to be complements in the empirical study of exchange rate exposures by Allayannis et al. (2001) and the theoretical work of Kazaz et al. (2005). Haushalter et al. (2007) document a negative association between cash holdings and currency swaps for manufacturing firms, but Geczy et al. (2006) find mixed evidence on whether hedging alternatives are complements or substitutes in the natural gas industry; the theoretical work of Chod et al. (2009) demonstrates that operational hedging can substitute for or complement derivatives use depending on the type of flexibility investment. In contrast, this paper documents direct evidence of operational hedging (through volatility-reducing acquisitions) substituting for derivatives use. By quantifying operational hedging, I examine how incremental changes affect financial hedging. I hypothesize that the amount of operational hedging created by an acquisition determines the degree of financial hedging adjustment. That is, the more an acquisition reduces volatility, the more financial hedging will decrease (controlling for the underlying tradable exposure). To test this hypothesis, I estimate the postacquisition change in derivatives use as a function of the acquisition's impact on volatility.

3. Data

Quarterly Federal Reserve filings offer unique and detailed information on BHC risk management activity as well as underlying risk exposures. The data set constructed from 1995–2003 Federal Reserve quarterly Y-9C filings includes the entire universe of bank holding companies with total consolidated assets of $150 million or more. Only top-tier BHCs are examined because risk may be managed across subsidiaries. The Y-9C filings categorize the derivatives into interest rate, foreign exchange, equity, and commodity/other contracts and separately report nontrading (hedging) versus trading positions. As noted earlier, virtually all BHC hedging is concentrated in interest rate derivatives, and there is information on the exposure to interest rate movements. Therefore, this paper focuses on these contracts.

Detailed deal information for BHCs involved in business combinations valued at $50 million or more is obtained from the SDC Platinum Mergers database.[2] There are 487 M&A deals identified involving a bank holding company. This deal information is combined with the panel of BHC quarterly filings. To be included in the sample, both parties must be bank holding companies. This excludes the acquisitions of nonbanks or partial acquisitions (such as the acquisition of bank branches or business segments). Of the 487 deals, BHC information was available and matched for 448 acquirers. Quarterly bank information, including derivatives usage, is matched to acquirers. All of these variables are winsorized at the 1st and 99th percentiles to remove potential outliers.

I control for the composition of the balance sheet because business structure may shape risk management decisions. In conjunction with time dummy variables, this serves as a proxy for inter-temporal differences in investing and risk management behavior. BHC control variables include the percentage of assets devoted to each of the main balance sheet categories each quarter. They are generated by dividing the BHC asset categories by BHC total assets (Schedule HC of the FR-Y9C). However, Allen and Saunders (1992) show that these quarter end numbers are susceptible to "window dressing" adjustments. They note that the most active window dressing on the asset side is in securities, federal funds, and loans. To minimize the potential impact of window dressing, the quarterly average is substituted for each of these three asset groups as well as total assets throughout the data set (Schedule HC-K of the FR-Y9C).

[2] A minimum deal value of $50 million limits possible data errors (such as deal values of zero) and inconsequential acquisitions. At the time of an acquisition, the median total assets for a BHC are ~$5.3 billion. The conclusions are robust to a minimum deal value of $20 million.

Historically, bank regulation has varied by state. Restrictions on bank merger activity were no exception. Some states began to permit M&A activity before 1970 whereas others resisted deregulation until the early 1990s (Strahan 2003). To control for differences in state legislation that might affect acquisition activity, the time since deregulation (Strahan 2003) is matched to each BHC by state, and the time since deregulation is calculated. And because Esty et al. (1999) document that time-series variations in interest rates affect bank acquisition activity, all model specifications include time dummy variables.

3.1. Measures of Interest Rate Exposure and Hedging

Interest rate exposure is expected to influence the level of interest rate hedging. Following the method of Flannery and James (1984), a measure of interest rate sensitivity—the one-year maturity gap—is constructed by subtracting the reported liability exposure subject to maturity or repricing within a year from the asset exposures subject to the same maturity or repricing time period (Schedule HC-H of the FR-Y9C). This net sensitivity is measured relative to the average quarterly total assets. The sensitivity measure used by Flannery and James is

$$Exposure_t = \frac{ST\ Assets_t - ST\ Liabilities_t}{TA_t}, \qquad (1)$$

where *ST Assets* are those assets that mature or reprice within one year, *ST Liabilities* are those liabilities that mature or reprice within one year, and *TA* is the quarterly average of consolidated assets.

Similar one-year gap measures of the mismatch between the asset and liability exposures are used by Brewer et al. (2001) and Purnanandam (2007).

The measure of financial hedging is the BHC's end-of-quarter gross notional amount of interest rate derivatives used for hedging. I analyze the changing use of derivatives for hedging purposes relative to total assets over one- and two-year horizons:

$$\Delta FinHedge_{it,\,t+4(8)} = \frac{IRH_{t+4\ (\text{or}\,t+8)} - IRH_t}{TA_t}, \qquad (2)$$

where *IRH* is the gross notional amount of derivatives used to hedge interest rate risk at quarter t, quarter t plus four quarters, or quarter t plus eight quarters.

To evaluate the acquisition's impact on risk management, the pre-acquisition and postacquisition entities must be comparable. Therefore, Δ*FinHedge* is adjusted for acquiring firms. The preacquisition use of derivatives is a pro forma combination of the target and acquirer, as is the total assets measure.

$$\Delta FinHedge_{it,\,t+4(8)} = \frac{IRH_{t+4\ (\text{or}\,t+8)} - (IRH_{A,\,t} + IRH_{T,\,t})}{TA_{A,\,t} + TA_{T,\,t}}, \qquad (2a)$$

where IRH_A is the gross notional amount of derivatives used to hedge by the acquirer, IRH_T is the gross notional amount of derivatives used to hedge by the target, TA_A is the acquirer's total assets, and TA_T is the target's total assets.

With this adjustment for acquiring firms, Δ*FinHedge* excludes mechanical changes in financial hedging because of the addition of the target. Although measuring the change in financial hedging relative to TA_t avoids declines because of changes in total assets over the time horizon rather than changes in derivatives use, I present alternative definitions of the change in financial hedging in §4.2 for robustness.

The gross notional amount of derivatives does not capture the true hedging position if some of the derivative contracts offset one another. This introduces an upward bias into the dependent variable for testing whether financial hedging decreases following operational hedging increases. Although net derivative positions would be preferable, using gross notional amounts biases the test against finding any such decline. Controlling for the change in interest rate exposure, a BHC's gross notional volume of derivatives would be expected to increase or remain constant following an acquisition for two reasons. First, acquiring a target without a derivatives program provides economies of scale with respect to the fixed costs of a hedging program. The target could start hedging without incurring the initial fixed costs of establishing its own program. This would increase derivatives use for the combined firm. Second, derivatives contracts are not normally cancelled; new ones are just written.[3] Therefore, the reorganization of any existing contracts with the combination of two firms would increase derivatives use. These factors bias the empirical analysis against finding a decrease in financial hedging. In addition, in a sample of nonfinancial firms, Graham and Rogers (2002) find only minor differences when using net and gross positions.

Intentionally or unintentionally, derivatives may be misclassified with respect to their use for hedging or trading. To control for this, an alternative dependent variable is generated:

$$\Delta TotalDeriv_{it,\,t+4(8)} = \frac{IR_{t+4\ (\text{or}\,t+8)} - IR_t}{TA_t}, \qquad (3)$$

where *IR* is the sum of the gross notional amount of derivatives used for either trading or hedging purposes.

This variable is less precise than the Δ*FinHedge* measure, but it provides a robustness check. Qualitatively similar results are found using both measures.

[3] Stulz (2004) discusses the fact that closing derivatives positions often involves purchasing an offsetting contract.

Table 1 Summary of Derivatives Use for Acquirers

	An acquirer in quarter t				Not an acquirer in quarter t				Difference between means	
	Obs.	Median	Mean	Std. dev.	Obs.	Median	Mean	Std. dev.	Diff.	Signif.
Panel A: All observations										
Hedging										
IR	448	0.000	0.016	0.034	54,165	0.000	0.007	0.050	0.009	***
FX	448	0.000	0.001	0.002	54,109	0.000	0.000	0.003	0.001	***
Equity	448	0.000	0.000	0.000	54,097	0.000	0.000	0.000	0.000	***
Commodity	448	0.000	0.000	0.000	54,093	0.000	0.000	0.000	0.000	
Trading										
IR	448	0.000	0.046	0.122	54,102	0.000	0.007	0.088	0.039	***
FX	448	0.000	0.012	0.039	54,093	0.000	0.002	0.022	0.010	***
Equity	448	0.000	0.000	0.000	54,078	0.000	0.000	0.001	0.000	***
Commodity	448	0.000	0.000	0.000	54,079	0.000	0.000	0.000	0.000	***
Panel B: Positive level of financial hedging										
Hedging										
IR	186	0.020	0.039	0.044	4,665	0.036	0.078	0.154	−0.040	***
FX	101	0.003	0.003	0.004	1,111	0.004	0.008	0.019	−0.004	***
Equity	9	0.000	0.000	0.000	527	0.001	0.002	0.003	−0.002	***
Commodity	0				0					
Trading										
IR	158	0.025	0.131	0.176	2,001	0.068	0.197	0.415	−0.066	***
FX	109	0.030	0.050	0.066	1,666	0.025	0.066	0.106	−0.016	***
Equity	18	0.002	0.002	0.001	539	0.002	0.003	0.004	−0.001	***
Commodity	31	0.000	0.000	0.000	363	0.000	0.000	0.000	0.000	***

Notes. The sample is split into observations in which an acquisition was made and observations in which one was not made. This table summarizes the level of derivatives use for hedging and trading purposes over the four derivatives categories of interest rate (IR), foreign exchange (FX), equity, and commodity. Derivatives use is measured as the gross notional amount relative to total assets. A positive level of hedging exists if the BHC uses the derivatives of interest in quarter t.

*** denotes statistical significance at the 1% level.

3.2. Summary of Interest Rate Exposure and Financial Hedging

Managing interest rate risk is a priority for BHCs' risk management. The summary statistics presented in Table 1 demonstrate that interest rate hedging and trading dominate other derivatives usage. The sample is divided into two groups: observations in which an acquisition is made and observations in which no acquisition is made. The median and mean derivatives levels relative to the quarterly average of total assets are presented for both subsamples. Panel A includes all observations and shows that BHCs, on average, exhibit a higher level of derivatives use for hedging, as well as trading, when an acquisition is made. Although these results suggest that acquisitions and derivatives are complements, both decisions may be correlated with firm size. Panel B includes only those observations in which the BHC uses the derivative contract and the reverse holds in this subsample. For active financial hedgers, the mean amount of interest rate hedging at the time of an acquisition is 3.9% of average quarterly total assets, compared to 7.8% when no acquisition is made. Derivatives are associated with acquisition activity, but acquirers hedge less within the realm of active hedgers. Although these are only summary statistics, this finding is consistent with the hypothesis that acquisitions contribute to risk management. Table 2 presents similar summary statistics but divides the observations into two groups based on whether the observation is a target in that period or not. This table shows that target BHCs exhibit a similar pattern, but—perhaps because of the small sample size—the difference is not statistically significant.

Although the statistics documented in Table 1 suggest that acquirers have different risk management practices than nonacquirers,[4] these BHCs simply may have a lower level of interest rate exposure—leading to less need for hedging. Therefore, Table 3 presents the average *Exposure* (Equation (1)) by acquirer and target status. Acquirers and targets each have significantly more interest rate exposure than other observations.[5] Acquirers have more than twice the

[4] Nonparametric tests of the difference in medians confirm these findings.

[5] *Exposure* is significantly higher for acquirers and targets than for BHCs not involved in M&A activity. This is true whether it is measured at the time of the M&A activity or four quarters prior to the event.

Table 2 Summary of Derivatives Use for Targets

	A target in quarter t				Not a target in quarter t				Difference between means	
	Obs.	Median	Mean	Std. dev.	Obs.	Median	Mean	Std. dev.	Diff.	Signif.
Panel A: All observations										
Hedging										
IR	448	0.000	0.009	0.061	54,165	0.000	0.007	0.050	0.002	
FX	448	0.000	0.000	0.001	54,109	0.000	0.000	0.003	0.000	***
Equity	448	0.000	0.000	0.000	54,097	0.000	0.000	0.000	0.000	
Commodity	448	0.000	0.000	0.000	54,093	0.000	0.000	0.000	0.000	
Trading										
IR	448	0.000	0.012	0.066	54,102	0.000	0.008	0.089	0.004	
FX	448	0.000	0.004	0.026	54,093	0.000	0.002	0.022	0.002	*
Equity	448	0.000	0.000	0.000	54,078	0.000	0.000	0.001	0.000	
Commodity	448	0.000	0.000	0.000	54,079	0.000	0.000	0.000	0.000	
Panel B: Positive level of financial hedging										
Hedging										
IR	64	0.027	0.068	0.158	4,787	0.035	0.077	0.152	−0.009	
FX	15	0.004	0.003	0.002	1,197	0.004	0.007	0.019	−0.004	***
Equity	4	0.001	0.002	0.002	532	0.001	0.002	0.003	0.000	
Commodity	0				0					
Trading										
IR	38	0.034	0.148	0.193	2,121	0.065	0.193	0.405	−0.044	
FX	33	0.022	0.066	0.079	1,742	0.026	0.065	0.104	0.001	
Equity	11	0.002	0.002	0.001	546	0.002	0.003	0.004	−0.001	***
Commodity	10	0.000	0.000	0.000	384	0.000	0.000	0.000	0.000	

Notes. The sample is split into observations in which the BHC was a target and observations in which it was not a target. This table summarizes the level of derivatives use for hedging and trading purposes over the four derivatives categories of interest rate (IR), foreign exchange (FX), equity, and commodity. Derivatives use is measured as the gross notional amount relative to total assets. A positive level of hedging exists if the BHC uses the derivatives of interest in quarter t.

*, *** denote statistical significance at the 10% and 1% levels, respectively.

average exposure to interest rate movements than observations in which no acquisition occurred (0.146 versus 0.068). The difference for targets is not quite as large but is still significant (0.118 versus 0.068). However, the larger exposure does not explain the difference in derivatives use. Merging BHCs have more exposure to interest rate movements but use financial hedging less than other institutions.

Further, acquisitions do not significantly change the average BHC's interest rate exposure. Acquisitions provide operational hedging if they reduce volatility or exposures. Panel A of Table 4 demonstrates that for the 439 acquisitions for which the interest rate sensitivity can be calculated for both the year before and the year after the acquisition, the average change in interest rate sensitivity ($\Delta Exposure$) is −0.010, with a standard deviation of 0.128. Thus, there is no statistically significant change in interest rate exposure over this window. Panel B presents the quartiles of $\Delta Exposure$ and the median value is even closer to zero

Table 3 Preacquisition Interest Rate Exposure

	An acquirer in quarter t			Not an acquirer in quarter t			Difference between means		
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	Diff.	t-stat.	Signif.
$Exposure_{t-4}$	446	0.146	0.137	49,680	0.068	0.191	0.078	11.968	***
	A target in quarter t			Not a target in quarter t			Difference between means		
$Exposure_{t-4}$	447	0.118	0.193	49,679	0.068	0.191	0.050	5.488	***

Notes. The sample is split into observations in which M&A activity occurred and those in which it did not occur, both for acquirers and targets. This table presents the average *Exposure* one year before the observation for each of these groups. This measure is the difference between the short term asset and liability exposure to interest rate movements relative to the quarterly average of total assets.

*** denotes statistical significance at the 1% level.

(−0.007) than the mean. This implies that although acquirers appear to manage risk differently, acquisitions do not materially alter interest rate exposure. This finding fits with the expectation that acquisitions are a cumbersome way to manage specific exposures.

3.3. Measures of Volatility

Having established that acquisitions do not significantly affect tradable risk, I focus on operational hedging in the spirit of Smith and Stulz (1985) and Van Mieghem (2007). Acquisitions may diminish potentially costly cash flow volatility without influencing tradable exposures. If firms manage total risk, there should be evidence of a trade-off between derivatives and corporate decisions that affect volatility. To evaluate the risk management contribution, I measure the change in volatility. I substitute income volatility for cash flow volatility for two reasons. First, Rountree et al. (2008) assert that earnings numbers are a better indicator of financial smoothness. Second, BHC data report the impact of financial hedging on quarterly income. Because calculations based on the BHC net income would include the effect of current financial hedging, a new variable, *Operational Income* (*OI*), is created:

$$OI_t = NetIncome_t - Derivative\_Income_t, \tag{4}$$

where *Derivative_Income* is the impact on income of derivatives held for hedging.

The net change in interest income and expense due to hedging is provided on Schedule HI of the FR-Y9C and is subtracted from the net income on a quarterly basis. From *OI*, volatility can be calculated without the influence of derivatives. This captures the fundamental stability before any risk management using financial hedges.

Next, I measure the level of operational hedging introduced by an acquisition. Comparing *OI* volatility before and after the acquisition introduces potential time-series concerns because the volatility change between the two periods could be attributed to numerous external factors such as management changes or broader economic conditions.[6] For a more precise estimate of how management expected the target to impact the acquirer's income volatility, I look at the quarterly income of the acquirer and target for the three years preceding the acquisition. Using these preacquisition numbers, I calculate the volatility of the firms had they been a combined entity. This pro forma volatility calculation provides an estimate of how the acquisition will impact the acquirer's volatility:

$$OV_{\text{Combined}} = \text{Std. dev.}\left(\frac{OI_{A,t-12}+OI_{T,t-12}}{TA_{A,t-12}+TA_{T,t-12}}, \ldots, \frac{OI_{A,t-1}+OI_{T,t-1}}{TA_{A,t-1}+TA_{T,t-1}}\right), \tag{5}$$

where OV_{Combined} is the operational volatility of the pro forma combined firm, $OI_{A,t}$ is the operational income of the acquirer at quarter t, and $OI_{T,t}$ is the operational income of the target at quarter t.

The volatility of the 12 combined quarterly observations is compared to the volatility of the 12 quarterly observations of the acquirer alone, i.e.,

$$OV_{\text{Acquirer}} = \text{Std. dev.}\left(\frac{OI_{A,t-12}}{TA_{A,t-12}}, \ldots, \frac{OI_{A,t-1}}{TA_{A,t-1}}\right), \tag{6}$$

where OV_{Acquirer} is the operational volatility of the acquirer alone.

The resulting effect is calculated as

$$\Delta OpHedge = \frac{OV_{\text{Acquirer}} - OV_{\text{Combined}}}{OV_{\text{Acquirer}}}, \tag{7}$$

where $\Delta OpHedge$ is the expected percentage change in operational volatility due to the acquisition (the measure of operational hedging).

4. Analysis and Results

Section 2 presented three testable hypotheses pertaining to operational hedging and risk management. In this section, I empirically investigate these predictions.

4.1. Do Acquisitions Provide Operational Hedging?

To consider the potential role of operational hedging, I first explore whether acquisitions can reduce volatility. $\Delta OpHedge$ (Equation (7)) is generated for a sample of 246 pairs of acquirers and targets for which both are bank holding companies and have at least three years of data before the acquisition. A deal's $\Delta OpHedge$ measures the acquisition's expected impact on income volatility. $\Delta OpHedge$ is positive when the volatility of the pro forma combined net income is smaller than that of the acquirer alone, implying that the acquisition would reduce income volatility ceteris paribus. Lower volatility indicates operational hedging benefits or potential savings associated with lower costs of convex taxation, potential financial distress, and/or external capital.

Table 4 shows that BHC acquisitions, on average, increase operational hedging by reducing income

[6] Although the combined volatility is calculated using ex ante data to avoid the impact of time effects and operational changes, there is a 63% correlation between this number and actual postacquisition volatility.

Table 4 Acquisitions' Impact on Risk

Panel A: Means

	Obs.	Mean	Std. dev.	*t*-stat.	Significance
Δ*Exposure*	439	−0.010	0.128	−1.64	—
Δ*OpHedge*	246	0.055	0.111	7.728	***

Panel B: Quartiles

	Obs.	25th	Median	75th
Δ*Exposure*	439	−0.071	−0.007	0.047
Δ*OpHedge*	246	0.004	0.031	0.090

Notes. To evaluate potential operational hedging provided by the acquisitions, the impact on interest rate sensitivity and operational income volatility is measured. Δ*Exposure* is the change in exposure to interest rate movements from four quarters before the acquisition to four quarters after the acquisition. Δ*OpHedge* measures the difference between the prior 12 quarters' income (relative to total assets) volatility of the acquirer alone (*Vol_Acquirer*) versus the prior 12 quarters if the target and acquirer were a combined entity over that period (*Vol_Combined*) and divides this by the volatility of the acquirer alone. For Δ*OpHedge*, there are 246 acquisitions where income data is available for both the target and acquirer for the 12 quarters preceding the acquisition, and a positive mean/median indicates that volatility decreased with the acquisition and that operational hedging increased.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

volatility. The mean volatility decreases 5.5%, which is statistically different from zero at the 1% level. However, as the skewness of this variable may lead to the incorrect rejection of the null, I report the quartiles in panel B. The median acquisition decreases volatility more than 3% and a Wilcoxon sign rank test shows that this is significantly different from zero. Furthermore, this average decrease is not driven by outliers because 79% of acquisitions create operational hedging. This is not surprising because the combination of two imperfectly correlated cash flows should reduce volatility. These results verify Hypothesis 1: acquisitions can provide operational hedging. However, it is not clear whether managers recognize the potential risk management benefits of lower volatility. Managers pursue M&A activities for any number of motivations, only one of which may be hedging. Having established the hedging benefits, I now use acquisitions to investigate firm risk management practices.

4.2. Do Firms Manage Total Volatility?

If managers recognize the potential hedging benefits of acquisitions and worry about total—not just transactional—risk, postacquisition financial hedging should adjust to reflect the increased operational hedging. To examine whether acquisitions affect financial hedging, I estimate the following regression:

$$\Delta FinHedge_{it,\,t+4(8)} = Acquirer_{it} + \Delta Exposure_{it,\,t+4(8)} + \Sigma BHC_{it} + \Sigma \Delta BHC_{it,\,t+4(8)} + Yr_t + \varepsilon_{it}, \quad (8)$$

where Δ*FinHedge* is the change in hedging relative to total assets over the next four (or eight) quarters; *Acquirer* is a binary variable equaling unity if an acquisition is made that quarter; Δ*Exposure* is the change in net interest rate exposure over the next year (one-year maturity gap); *BHC* is a vector of control variables for the bank holding company composition, which include the log of the quarterly average of total assets and the BHC asset categories (securities, federal funds sold, and securities repurchase under agreements to resell, loans and lease financing receivables, trading assets, premises and fixed assets, other real estate owned, investments in unconsolidated subsidiaries and associated companies, customer's liabilities on acceptances outstanding, intangible assets, other assets) divided by the quarterly average of total assets; Δ*BHC* is a vector of the changes in the quarterly assets and BHC categories over the same period as the dependent variable; and *Yr* is year dummy variables.

Addressing the endogenous relationship between acquisitions and derivatives—as both appear to be related to risk management—is important for unbiased and consistent estimates of how firms hedge. An acquisition's impact on financial hedging is estimated using an instrumental variable approach. Because a good instrument predicts the endogenous variable without otherwise being associated with the dependent variable (Wooldridge 2002), *Dereg, Private*, and Ln(*Assets*) are selected as instruments, where *Dereg* is the time since the M&A deregulation for each BHC, by state, and *Private* is a binary variable equaling unity if the BHC is not registered with the SEC. These variables are correlated with the decision to acquire but not with adjustments in derivatives use.[7]

Table 5 presents the two-stage least-squares within estimates.[8] Fixed effects are included to control for unobserved firm-level heterogeneity. The first row of coefficients, *Acquirer*, shows that there is a statistically significant decline in financial hedging over the one and two years following an acquisition. Financial hedging decreases even after controlling for changes in interest rate sensitivity, *Exposure*. The positive coefficients for *Exposure* are consistent with the expectation that derivatives use is positively related to tradable risk exposure. However, this model assumes that *Exposure* is exogeneous. If BHCs consider their short term exposure to interest rate movements to be a risk management choice, this is not true. Although there is no good instrumental variable available,

[7] It should be noted that the coefficient estimates presented in this paper are robust to alternative instrument choices.

[8] Estimating the models with robust OLS or fixed effects (without instrumental variables) provides qualitatively similar results.

Table 5 Postacquisition Use of Derivatives for Hedging

	One-year horizon		Two-year horizon	
	(1)	(2)	(3)	(4)
Acquisition	−0.297*	−0.302*	−0.655**	−0.627*
	(0.083)	(0.095)	(0.040)	(0.051)
Δ*Exposure*	0.007***		0.006	
	(0.007)		(0.150)	
Constant	−0.018	−0.019	−0.315***	−0.271**
	(0.480)	(0.500)	(0.005)	(0.017)
No. of obs.	45,248	45,314	36,046	36,099
No. of groups	2,591	2,591	2,250	2,251

Notes. This table examines the change in financial hedging following an acquisition using a two-stage fixed effects model. The dependent variable is the change in interest rate hedging relative to total assets (Δ*FinHedge*) in the year (or two years) following the observation. *Acquirer* is an indicator variable equaling unity if the BHC makes an acquisition during quarter *t*. The instrumental variables for *Acquirer* are *Dereg*, *Private*, and Ln(*Assets*). *Dereg* is the time since the M&A deregulation for each BHC, by state, and *Private* is a binary variable equaling unity if the BHC is not registered with the SEC. Δ*Exposure* is the change in interest rate exposure during the period over which the change in interest rate hedging is measured. *BHC* and Δ*BHC* control variables are included as well as *Yr* dummy variables. *p*-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6 Postacquisition Use of Total Derivatives

	One-year horizon		Two-year horizon	
	(1)	(2)	(3)	(4)
Acquisition	−0.370*	−0.373*	−0.793**	−0.771**
	(0.065)	(0.072)	(0.035)	(0.039)
Δ*Exposure*	0.004		0.001	
	(0.140)		(0.790)	
Constant	−0.067**	−0.069**	−0.464***	−0.433***
	(0.027)	(0.029)	(0.000)	(0.001)
No. of obs.	45,210	45,246	36,010	36,039
No. of groups	2,590	2,590	2,250	2,251

Notes. This table examines the change in financial hedging following an acquisition using a two-stage fixed effects model. The dependent variable is the change in the ratio of total derivatives use relative to total assets (Δ*TotalDeriv*) in the year (or two years) following the observation. *Acquirer* is an indicator variable equaling unity if the BHC makes an acquisition during quarter *t*. The instrumental variables for *Acquirer* are *Dereg*, *Private*, and Ln(*Assets*). *Dereg* is the time since the M&A deregulation for each BHC, by state, and *Private* is a binary variable equaling unity if the BHC is not registered with the SEC. Δ*Exposure* is the change in interest rate exposure during the period over which the change in interest rate hedging is measured. *BHC* and Δ*BHC* control variables are included as well as *Yr* dummy variables. *p*-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

robustness checks are included to minimize the potential misspecification. Year dummies remove intertemporal variations in the choice of exposure and the fixed effects remove BHC-level time invariant preferences.[9] Lastly, the models are estimated without the inclusion of the variable, *Exposure*, in columns 2 and 4. Regardless of the specification, the coefficient on *Acquirer* is negative and significant. Volatility reducing events lead to less financial hedging. This suggests that firms manage aggregate risk, not just tradable exposures.

The Equation (8) dependent variable is the amount of interest rate derivatives used for hedging. Because derivatives use may be misclassified, Table 6 presents the estimates of the postacquisition change in derivatives using the combined total derivatives:

$$\begin{aligned}\Delta TotalDeriv_{it,\,t+4(8)} &= Acquirer_{it} + \Delta Exposure_{it,\,t+4(8)} \\ &\quad + \Sigma BHC_{it} + \Sigma \Delta BHC_{it,\,t+4(8)} + Yr_t + \varepsilon_{it}, \end{aligned} \quad (9)$$

where Δ*TotalDeriv* is the change in total interest rate derivatives (both hedging and trading) relative to total assets over the next four (or eight) quarters.

[9] Although the control variable coefficient estimates are not reported in Table 5, they are available in the online appendix (provided in the e-companion). An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

Once again, derivatives use decreases significantly over both the one and two-year horizons, and this is after controlling for the underlying risk exposure and the composition of the BHC.

To further verify the robustness of these results, I vary both the definition of change in derivatives use as well as the event window. First, I present an alternative definition of both Δ*FinHedge* and Δ*TotalDeriv*, where, unlike the original definition, total assets is not held constant across time:

$$\Delta FinHedge - Alt_{it,\,t+4(8)} = \frac{IRH_{t+4\ (\text{or}\,t+8)}}{TA_{t+4\ (\text{or}\,t+8)}} - \frac{IRH_t}{TA_t}, \quad (10)$$

$$\Delta TotalDeriv - Alt_{it,\,t+4(8)} = \frac{IR_{t+4\ (\text{or}\,t+8)}}{TA_{t+4\ (\text{or}\,t+8)}} - \frac{IR_t}{TA_t}. \quad (11)$$

As noted earlier, rescaling these measures by each period's total assets allows decreases to result from changes in BHC size as well as the use of derivatives. Second, I examine the sensitivity of the event window choice by evaluating the change in derivatives over the periods $t-4$ to $t+4$ in addition to the baseline choices of periods t to $t+4$ and periods t to $t+8$:

$$\Delta FinHedge_{it-4,\,t+4} = \frac{IRH_{t+4} - IRH_{t-4}}{TA_{t-4}}. \quad (12)$$

Equation (12) requires adjustment to ensure the comparability of preacquisition and postacquisition periods for acquiring firms just as $\Delta FinHedge_{it,\,t+4}$ did.

Table 7 Robustness of Postacquisition Change in Derivatives Use

	Δ*FinHedge-Alt*		Δ*TotalDeriv-Alt*		$\Delta FinHedge_{t-4,t+4}$	
	One year (1)	Two year (2)	One year (3)	Two year (4)	Δ*FinHedge* (5)	Δ*FinHedge-Alt* (6)
Acquisition	−0.273*	−0.480**	−0.340*	−0.666**	−0.394***	−0.427**
	(0.077)	(0.034)	(0.060)	(0.029)	(0.010)	(0.023)
Δ*Exposure*	0.006***	0.004	0.007***	0.005	0.003	0.003
	(0.006)	(0.183)	(0.007)	(0.277)	(0.190)	(0.337)
Constant	0.046*	−0.092	0.034	−0.187*	0.459***	0.348*
	(0.052)	(0.139)	(0.215)	(0.084)	(0.005)	(0.085)
No. of obs.	45,184	35,984	45,210	36,010	35,877	35,877
No. of groups	2,591	2,250	2,590	2,250	2,252	2,252

Notes. This table examines the change in financial hedging following an acquisition using a two-stage fixed effects model. The model is estimated separately using three alternative dependent variables. Both Δ*FinHedge* and Δ*TotalDeriv* are defined as the change in the ratio of derivatives use relative to total assets in the year (or two years) following the observation (versus holding total assets constant). Then Δ*FinHedge* is calculated over periods $t-4$ to $t+4$ (versus 4 to $t+4$). *Acquirer* is an indicator variable equaling unity if the BHC makes an acquisition during quarter t. The instrumental variables for *Acquirer* are *Dereg*, *Private*, and Ln(*Assets*). *Dereg* is the time since the M&A deregulation for each BHC, by state, and *Private* is a binary variable equaling unity if the BHC is not registered with the SEC. Δ*Exposure* is the change in interest rate exposure during the period over which the change in interest rate hedging is measured. *BHC* and Δ*BHC* control variables are included as well as *Yr* dummy variables. *p*-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Therefore, all of the $t-4$ data are a pro forma combination of the target and acquirer when an acquisition occurs:

$$\Delta FinHedge_{it-4,\,t+4} = \frac{IRH_{t+4} - (IRH_{A,\,t-4} + IRH_{T,\,t-4})}{TA_{A,\,t-4} + TA_{T,\,t-4}}. \quad (12a)$$

I also calculate Δ*FinHedge-Alt* over this alternative event window. Table 7 presents the results using these modified dependent variables:

$$\Delta FinHedge - Alt_{it,\,t+4(8)} = Acquirer_{it} + \Delta Exposure_{it,\,t+4(8)} + \Sigma BHC_{it} + \Sigma \Delta BHC_{it,\,t+4(8)} + Yr_t + \varepsilon_{it}, \quad (13)$$

$$\Delta TotalDeriv - Alt_{it,\,t+4(8)} = Acquirer_{it} + \Delta Exposure_{it,\,t+4(8)} + \Sigma BHC_{it} + \Sigma \Delta BHC_{it,\,t+4(8)} + Yr_t + \varepsilon_{it}, \quad (14)$$

$$\Delta FinHedge_{it-4,\,t+4} = Acquirer_{it} + \Delta Exposure_{it-4,\,t+4} + \Sigma BHC_{it} + \Sigma \Delta BHC_{it-4,\,t+4} + Yr_t + \varepsilon_{it}, \quad (15)$$

$$\Delta FinHedge - Alt_{it-4,t+4} = Acquirer_{it} + \Delta Exposure_{it-4,t+4} + \Sigma BHC_{it} + \Sigma \Delta BHC_{it-4,\,t+4} + Yr_t + \varepsilon_{it}. \quad (16)$$

It should be noted that Equations (15) and (16), which vary the event window to span $t-4$ through $t+4$, include Δ*Exposure* and Δ*BHC* variables from the corresponding time period. The estimated coefficients presented in Table 7 are consistent with the baseline results. Regardless of the scaling of derivatives use or the event window, there is a statistically significant decrease in derivatives use following acquisitions.

Tables 5–7 provide evidence of a trade-off between operational hedging and derivatives and support Hypothesis 2: firms manage aggregate risk, not just transactional exposures. This finding indicates that firms manage the expected costs of volatility. As these costs vary by firm, I investigate whether firms manage aggregate risk when volatility is less costly. Some firms—such as "too big to fail" banks—face mitigated potential costs of distress and therefore should find cash flow volatility less costly. Although these firms may still use derivatives to manage minimum capital requirements or managerial employment risk, I expect the largest BHCs to be less concerned with volatility and therefore less responsive to increased operational hedging. To test this hypothesis, I examine how firm size affects the change in derivatives. I run the baseline model specification (Equation (8)) for firms in the top 1% of quarterly total assets separately from the rest of the sample.[10] Table 8 presents these results. The *Acquirer* coefficient in the first row shows that the largest firms do not significantly reduce their use of derivatives following an acquisition, unlike other BHCs. Those firms least likely to find volatility costly (those with lower probability of financial distress or information asymmetry concerns) do not appear to manage aggregate

[10] This conclusion is robust to defining the largest 1% by observation quarterly size or by BHC mean size. These populations are estimated separately because an interaction term would necessitate additional instruments.

Table 8 Postacquisition Use of Derivatives with Varying Costs of Volatility

	One-year horizon		Two year-horizon	
	Bottom 99%	Largest 1%	Bottom 99%	Largest 1%
	(1)	(2)	(3)	(4)
Acquisition	−0.310*	0.139	−0.703**	0.234
	(0.091)	(0.710)	(0.040)	(0.430)
Δ*Exposure*	0.006**	0.056	0.004	0.230
	(0.026)	(0.590)	(0.360)	(0.320)
Constant	0.004	−2.550	−0.239***	−17.060
	(0.880)	(0.610)	(0.006)	(0.480)
No. of obs.	44,725	523	35,629	417
No. of groups	2,578	31	2,237	26

Notes. This table examines the change in financial hedging following an acquisition using a two-stage fixed effects model. The model is estimated separately for the top 1% of BHC, defined as quarterly assets, and for the rest of the sample. The dependent variable is the change in interest rate hedging relative to total assets (Δ*FinHedge*) in the year (or two years) following the observation. *Acquirer* is an indicator variable equaling unity if the BHC makes an acquisition during quarter t. The instrumental variables for *Acquirer* are *Dereg*, *Private*, and Ln(*Assets*). *Dereg* is the time since the M&A deregulation for each BHC, by state, and *Private* is a binary variable equaling unity if the BHC is not registered with the SEC. Δ*Exposure* is the change in interest rate exposure during the period over which the change in interest rate hedging is measured. *BHC* and Δ*BHC* control variables are included as well as *Yr* dummy variables. *p*-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

risk. This result provides additional evidence that the costs of volatility cause firms to manage total risk.

Unfortunately, using the gross notional amounts of derivatives prohibits interpreting the economic significance of the estimated coefficients. The two-year horizon coefficients are larger in magnitude. This may indicate that firms take time to incorporate operational hedging into their aggregate risk management practices, but it is not certain given the data do not reflect net positions.

4.3. Are Financial and Operational Hedges Substitutes?

The empirical evidence presented thus far demonstrates that acquisitions often provide operational hedging and that managers consider this when making other risk management decisions. To further understand the role of operational hedging, I test whether there is additional evidence of risk management substitution. Acquisitions vary in their contribution to risk management. If financial and operational hedging are substitutes, an acquisition's impact on derivatives use should be related to the amount of operational hedging created.[11] Acquisitions creating the most operational hedging should lead to the largest declines in financial hedging. To examine this basic relationship, I limit the sample to those firms that made acquisitions and regress Δ*OpHedge*, the measure of operational hedging introduced in Equation (7), against the change in derivatives use as follows:

$$\begin{aligned}\Delta FinHedge_{it,\,t+4(8)} &= \Delta OpHedge_{it} + \Delta Exposure_{it,\,t+4(8)} \\ &\quad + \Sigma BHC_{it} + \Sigma \Delta BHC_{it,\,t+4(8)} + \varepsilon_{it}. \qquad (17)\end{aligned}$$

The baseline results use three years of data to calculate Δ*OpHedge* as discussed in §3.3. For robustness, I also calculate this measure using two and four years of prior quarterly data.

Table 9 presents the estimated coefficients with panel A using the measure of operational hedging calculated with 8 prior quarters of data ($\Delta OpHedge_{2\text{ years}}$), panel B using 12 prior quarters ($\Delta OpHedge_{3\text{ years}}$, the baseline), and panel C using 16 quarters ($\Delta OpHedge_{4\text{ years}}$). Because Δ*OpHedge* is positive when the acquisition contributes to operational hedging, the consistently statistically significant negative coefficients in panels A and B demonstrate that the postacquisition hedging is negatively related to the amount of operational hedging. Panel C loses some statistical significance with the longer panel length required to calculate the four-year measure. However, the empirical analysis documents a widespread decrease in derivatives use even though using gross notional amounts biases the results in the opposite direction. Acquisitions providing more operational hedging are followed by larger decreases in financial hedging. Those generating less operational hedging experience a smaller change in financial hedging. Although interpreting the magnitude of the coefficients is difficult given the use gross notional amounts, this evidence supports Hypothesis 3: operational hedging and financial hedging are substitutes. Firms substitute the newly created operational hedging for their prior use of derivatives. Risk management does not have to motivate the M&A activity for managers to recognize the operational hedging benefits and substitute away from the use of derivatives.

5. Conclusion

In this paper, I examine how firms manage risk. The theoretical works of Smith and Stulz (1985), Froot et al. (1993), and Van Miegham (2007) assert that firms manage risk to limit potentially costly cash flow volatility. However, the existing empirical evidence is mixed. I provide direct support for the hypothesis that firms manage aggregate volatility, not just specific transactional exposures. In addition, I find that

[11] A simultaneous equation system also is estimated to provide additional support for the substitution hypothesis. However, given the potential misspecification concerns with any structural model, I only include it in the appendix.

Table 9 Volatility and the Change in Financial Hedging

	One- year horizon		Two-year horizon	
	(1)	(2)	(3)	(4)
	Panel A: Two years			
Δ*OpHedge*	−0.019**	−0.017*	−0.035***	−0.045**
	(0.026)	(0.072)	(0.007)	(0.012)
Δ*Sensitivity*	0.048*	0.047	0.055**	0.045
	(0.090)	(0.117)	(0.026)	(0.136)
Constant	−0.106**	−0.124***	−0.237***	−0.311***
	(0.015)	(0.004)	(0.000)	(0.000)
No. of obs.	299	287	271	260
R^2	0.069	0.081	0.117	0.175
	Panel B: Three years			
Δ*OpHedge*	−0.018**	−0.017*	−0.037***	−0.044**
	(0.015)	(0.087)	(0.002)	(0.014)
Δ*Sensitivity*	0.060	0.065	0.070**	0.070*
	(0.130)	(0.140)	(0.030)	(0.064)
Constant	−0.144***	−0.165***	−0.345***	−0.459***
	(0.007)	(0.002)	(0.000)	(0.000)
No. of obs.	236	225	212	202
R^2	0.089	0.102	0.142	0.241
	Panel C: Four years			
Δ*OpHedge*	−0.011	0.000	−0.036**	−0.038
	(0.388)	(0.977)	(0.025)	(0.152)
Δ*Sensitivity*	0.066	0.066	0.075**	0.097*
	(0.220)	(0.285)	(0.043)	(0.090)
Constant	−0.088	−0.114*	−0.242***	−0.281***
	(0.106)	(0.053)	(0.000)	(0.000)
No. of obs.	179	169	160	151
R^2	0.090	0.088	0.196	0.216
BHC controls	Yes	Yes	Yes	Yes
Δ*BHC Controls*		Yes		Yes

Notes. This table shows how changes in operational hedging affect financial hedging using an OLS regression with standard errors clustered at the BHC level. The dependent variable is the change in interest rate hedging relative to total assets (Δ*FinHedge*) in the year (or two years) following the observation. Δ*OpHedge* measures the change in volatility due to the acquisition and is calculated using either two, three, or four years of data preceding the acquisition. A positive Δ*OpHedge* implies that operational hedging increased as the volatility of the combined target and acquirer is smaller than that of the acquirer alone. The negative coefficient on Δ*OpHedge* indicates that the deal's contribution to reducing volatility is followed by a decrease in financial hedging. Δ*Exposure* is the change in interest rate exposure during the period over which the change in interest rate hedging is measured. *BHC* and Δ*BHC* control variables are included. *p*-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

BHCs substitute the operational hedging created by acquisitions for financial hedging.

This paper presents two improvements to the existing literature's methods. First, operational hedging is defined as the change in volatility. This follows theory rather than using less precise categorical proxies for flexibility or diversification. Second, all model specifications control for changes in the underlying level of tradable risk. Without this control, it is impossible to attribute changing risk management practices to reduced volatility or to changing tradable exposures. This level of empirical analysis requires information on firm financial hedging and exposures. Because only BHCs offer this quality of data, the banking industry offers the best opportunity for understanding the interaction of financial and operational hedging.

Using BHC data, I analyze the impact of acquisitions on the use of derivatives for hedging. Acquisitions provide a large shift in the level of cash flow volatility. Not only do they reduce volatility significantly in the majority of acquisitions, but also firms decrease their use of financial hedging over the one and two-year periods following an acquisition. That is, firms reduce their use of derivatives after an operational hedge is introduced. This result holds after controlling for changes in the tradable exposures as well as the endogeneity of acquisition decisions. If firms only managed specific transactional exposures, the change in cash flow volatility would not affect their financial hedging. Therefore, this evidence implies that the costs of volatility matter for firms and affect their risk management choices. And the result holds when I evaluate firms with varying expected costs of volatility. The largest BHCs, which face lower information asymmetry and likelihood of distress, do not actively manage aggregate risk.

Further, I document the direct substitution of operational hedging for financial hedging. Although this paper does not attempt to answer whether firms use acquisitions specifically as risk management tools, it uses an acquisition's impact on volatility to measure how financial hedging adjusts. There is a significant negative association between the levels of operational and financial hedging. Derivatives use decreases more following acquisitions providing more operational hedging benefits. This evidence suggests that BHCs substitute hedging choices and that risk management is endogenous to other corporate decisions. This conclusion has vast implications for analysis and the econometric specification within the risk management, operations research, and corporate finance literatures.

Even though this paper's results are most applicable to bank risk management, there is reason to believe they may extend to nonfinancial firms. First, many nonfinancial firms use derivatives to hedge, and there is some evidence that hedging within such firms is related to other corporate finance decisions (Chowdhry 1995, Graham and Rogers 2002).[12] Second, BHCs' principal exposure is

[12] Nonfinancial firms face similar risk management motivations as banks. For example, a bank's reputation is critical core activities such as loan sales (Dahiya et al. 2003), interactions with regulators (Cummins et al. 2006), raising capital (Penas and Unal 2004), and

interest rate risk, which can be managed with low basis risk derivatives. For the primary exposures of nonfinancial firms, derivatives may be less useful or not available—thereby increasing the relative importance of operational hedging (Hirshleifer 1988). If BHCs actively manage aggregate risk, then ceteris paribus firms less able to manage specific exposures will focus even more on the potential costs of total risk. However, the examination of these questions for nonfinancial firms is left to future research.

This paper establishes that risk management is an integral corporate decision, not a secondary activity. Yet the existing literature rarely considers this relationship for financial or nonfinancial firms. Identifying this endogeneity is critical for research in risk management as well as other areas, including capital structure and diversification. The substitution of operational hedging for financial hedging demonstrates that firm-level cash flow volatility, not just specific transaction exposure, determines risk management policy. If nonfinancial firms also recognize the operational hedging contribution of an acquisition, it is likely that other decisions, such as leverage and project selection, also are jointly determined with risk management. The relationship between hedging and acquisitions has broad implications for interindustry differences in the diversification discount because only certain industries can hedge their primary inputs using derivatives. Because the value of hedging remains an open question (Jin and Jorion 2004, Bartram et al. 2007, Rountree et al. 2008), these results suggest that it may be worthwhile to consider the endogeneity of risk management and corporate decisions.

The key insight of this paper is that firms manage aggregate risk, not just specific transactional exposures. This paper is limited to the extent that it cannot prescribe precise directives on how to implement a comprehensive risk management plan. However, firms with larger risk management expenditures, such as those with large distress or external financing costs, have the most opportunity to improve the efficiency of their risk management decisions. Although evaluating financial and operational hedging jointly is a complex undertaking, it has the potential to reduce risk management costs by minimizing redundant expenses. This research also implies that firms with long term exposures may find operational hedging a useful substitute for derivatives use.

preventing bank runs (Black et al. 1978), and large swings in cash flows might raise questions regarding the bank's long term viability. Likewise, reputation is a significant concern for a broad array of managers such as those in high-tech firms (Gleason et al. 2005), in the insurance industry (Cowan and Power 2001), and in firms relying on implicit contracts (Karpoff et al. 2008) and may motivate similar risk management expenditures.

6. Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

Appendix

I also examine the interaction between financial and operational hedging in a simultaneous equation framework. Using three-stage least squares (3SLS), the two equation system is estimated. To incorporate the panel attributes of the data, I demean the data before estimating the coefficients. The equations are based on the results of Tables 5 and 6 and model the decision to acquire and the choice of interest rate derivatives use:

$$FinHedge_{it} = Acquirer_{it} + Exposure_{it} + \Sigma BHC_{it} + \varepsilon_{it}, \quad (18)$$

$$Acquirer_{it} = FinHedge_{it} + Private_{it} + Dereg_{it} + \Sigma BHC_{it} + \varepsilon_{it}. \quad (19)$$

The 3SLS approach has the benefit of incorporating the correlation of errors across equations. However, simultaneous equation estimation assumes a well-specified structural model, and any misspecification is compounded across the system estimates. Given that the existing literature does not specifically address which factors determine the level of financial and operational hedging, the system equation estimates are presented only to show that the substitution hypothesis is robust to this approach.

Table A.1 presents some evidence that financial hedging and operational hedging are simultaneously determined.

Table A.1 Simultaneity and Risk Management Choices

	System 1		System 2		System 3	
	FinHedge (1)	Acquisition (2)	FinHedge (3)	Acquisition (4)	FinHedge (5)	Acquisition (6)
Acquirer	−0.257*** (0.000)		−0.089 (0.110)		−0.030 (0.610)	
FinHedge		−0.936*** (0.000)		−0.843*** (0.000)		−0.519** (0.031)
Exposure	0.008*** (0.000)		0.011*** (0.000)		0.011*** (0.000)	
Private		−0.017*** (0.001)		−0.029*** (0.000)		−0.029*** (0.000)
Dereg				−0.003*** (0.009)		
Constant	0.000 (0.160)	−0.007*** (0.000)	0.003*** (0.000)	0.001 (0.310)	0.003*** (0.000)	−0.004** (0.037)
No. of obs.	48,615		47,283		48,615	
BHC controls	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies		Yes	Yes		Yes	Yes

Notes. This table presents three systems of simultaneous equations. The systems model the relationship between interest rate hedging and acquisitions. All variables are demeaned to incorporate the panel attributes of the data. For the first equation, the dependent variable is the level of interest rate hedging relative to the quarterly average of total assets. *Exposure* is the level of interest rate exposure. For the second equation, the dependent variable is an indicator variable equaling unity if the BHC made an acquisition. *Dereg* is the time since the M&A deregulation for each BHC, by state, and *Private* is a binary variable equaling unity if the BHC is not registered with the SEC. *BHC* control variables are included. *p*-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The coefficients in the first two rows indicate that acquisitions and derivatives use are jointly determined. All of the coefficients are negative indicating causality in both directions, but the statistical significance of acquisitions varies with the model specification. Columns (2), (4), and (6) show that the use of derivatives is negatively associated with acquisitions for each system. This evidence confirms the substitution hypothesis.

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