Journal of Financial Economics 101 (2011) 515–532

Contents lists available at ScienceDirect

Journal of Financial Economics

journal homepage: www.elsevier.com/locate/jfec

The role of risk management in mergers and merger waves ☆

Jon A. Garfinkel [a,1], Kristine Watson Hankins [b,*]

[a] Henry B. Tippie College of Business, University of Iowa, 108 PBB, Iowa City, IA 52242, USA
[b] Gatton College of Business and Economics, University of Kentucky, 445K Gatton College, Lexington, KY 40506, USA

ARTICLE INFO

Article history:
Received 8 April 2010
Received in revised form
29 October 2010
Accepted 23 November 2010
Available online 12 April 2011

JEL classification:
G34
G32

Keywords:
Merger waves
Vertical integration
Risk management

ABSTRACT

We show that merger activity and particularly waves are significantly driven by risk management considerations. Increases in cash flow uncertainty encourage firms to vertically integrate and this contributes to the start of merger waves. These effects are incremental to previously identified causes of wave activity. Our risk management hypothesis is further supported by cross-sectional differences in the likelihood that a firm vertically integrates, and by the post-acquisition characteristics of vertically integrating firms. These results are consistent with the view (from the industrial organization literature) that vertical integration is an operational hedging mechanism that reduces the cost of increased uncertainty.

© 2011 Elsevier B.V. All rights reserved.

1. Introduction

Mergers and acquisitions (M&A) are among the most important corporate finance events. In 2007, the aggregate deal value for acquisitions of U.S. targets (from Securities Data Company (SDC)) was $1.37 trillion. Compared to aggregate capital expenditure activity (by Compustat firms) of $1.85 trillion, this strongly suggests that acquisition activity represents a large proportion of corporate investment.[2]

Since a significant amount of acquisition activity occurs during merger waves, the literature on such waves has received renewed academic interest. Shleifer and Vishny (2003), Rhodes-Kropf, Robinson, and Viswanathan (2005), and Cai and Vijh (2007) all suggest that waves are at least associated with, if not driven by, high valuations of bidder stock. Mitchell and Mulherin (1996), Harford (2005), and Ovtchinnikov (2010) attribute waves to economic shocks.[3] Goel and Thakor (2010) argue that CEO envy combines with neoclassical shocks to generate merger waves.

This paper adds to our understanding of merger activity and particularly waves, by studying the role of risk management in them. Our research builds on the above evidence that neoclassical economic relationships have important influences on merger waves. However, recognizing that merger waves follow economic shocks leaves important questions unanswered. Do certain types of mergers (vertical, horizontal, conglomerate) predominate during a wave compared to non-wave periods? Is this (potential) merger-type variation across wave and non-wave periods related to the nature of firms' economic experiences? Do other elements such as uncertainty affect

☆ We thank Matt Billett, Brad Jordan, Shawn Thomas, Anand Vijh, Mark Walker, and an anonymous referee for helpful comments. We thank Scott Cederburg and Jill Kirby for research assistance.

* Corresponding author. Tel.: +1 859 257 7726.
E-mail addresses: jon-garfinkel@uiowa.edu (J.A. Garfinkel), kristine.hankins@uky.edu (K.W. Hankins).
[1] Tel.: +1 319 335 0943.

[2] In 2006, total M&A activity was $1.42 trillion and capital expenditures were $1.68 trillion. In 2005, M&A activity totaled $1.1 trillion while capital expenditures totaled $1.4 trillion.

[3] Harford (2005) suggests that behavioral explanations reflect the joint importance of economic shocks to the industry *and* the existence of sufficient capital liquidity to enable mergers.

0304-405X/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.jfineco.2011.03.011

merger choices and the likelihood of a wave? Answers to these questions have implications for corporate efficiency as well as regulatory policy.

Our results strongly suggest that risk management is an important component of merger waves, general (non-wave) industry merger activity, and firm-specific merger choice. Increases in firm-level cash flow uncertainty lead to the start of merger waves. Further, these uncertainty increases are a significant determinant of both individual firm and industry-level vertical integration activity (which we show are important components of waves). All of these results are incremental to the extant evidence that economic shocks and behavioral factors influence merger activity.

While our risk management perspective is new to the merger wave literature, there are several reasons why we might expect risk management to be relevant. First, a growing area of the finance literature recognizes that operational hedging may be accomplished via mergers (Amihud and Lev, 1981; Hirshleifer, 1988; Penas and Unal, 2004; Hankins, forthcoming). To the extent that other forms of risk management carry non-trivial costs or possibly fail to provide complete hedging (especially over longer periods), an alternative response to increased uncertainty is to merge or acquire.[4]

Second, a well-established strain of the industrial organization literature identifies vertical integration as a solution to contracting problems—problems which increase during periods of uncertainty. Williamson (1971) notes that evolving technology inhibits perfect contracts and suggests that vertical integration can address such contractual incompleteness. Carlton (1979) states that vertical integration is a risk management tool for firms facing potentially uncertain availability of inputs. To the extent that vertical integration plays an important role in merger waves (as we show it does), the connection between risk management and waves should be examined.

The recent volatility in commodity prices highlights the role of uncertainty in M&A activity and anecdotal evidence suggests that firms facing higher commodity prices are vertically integrating. On August 14, 2006, a *Wall Street Journal* article noted that "a hot commodities market … was encouraging vertical integration by manufacturers." (Wall Street Journal, 2006) More recently (December 1, 2009), the *Wall Street Journal* again reported a rise in the number of vertical integrations (Wall Street Journal, 2009). In that article, steelmaker Arcelor expressly stated that its vertical acquisitions were undertaken to hedge against price uncertainty.

Our paper proceeds as follows. We start by documenting heterogeneity in merger types during waves. Vertical integration is much more common during merger waves than during non-wave periods, and we directly tie the incidence of waves to the proportion of merger activity that is vertically integrated.

We then move on to our main contribution. Given the importance of vertical integration to waves, we study why this pattern might exist. Since industrial organization theory asserts that vertical integration is a risk management response to uncertainty, we examine the effects of cash flow uncertainty on the start of merger waves. We find that merger waves are more likely to start following periods when many firms in an industry experience increasingly volatile cash flows. This evidence suggests risk management is an economically important determinant of waves.

We confirm the importance of risk management to merger activity by extending our analysis beyond waves, and examining annual industry data as well as firm-level data. At the industry-year level, we find that increased cash flow uncertainty carries significant explanatory power for the percentage of vertically related mergers. We also find that individual firms' decisions to vertically integrate (after controlling for the decision to engage in an acquisition via a Heckman model) are positively influenced by cash flow uncertainty increases. These results both suggest the link between vertical integrations and uncertainty is robust and they support the importance of viewing vertical integration as a risk management technique.

Critical to our analysis is whether vertical integration *actually* provides operational hedging. In particular, Kedia, Ravid, and Pons (2008) question whether vertical integrations provide any benefit in the presence of price uncertainty. We present several pieces of evidence that vertical integration provides hedging benefits. First, Klein, Crawford, and Alchian (1978) and Williamson (1979) suggest that vertical integration is particularly useful in risk management when asset specificity is high. We show that the tendency to vertically integrate following increased uncertainty is stronger for firms with higher asset specificity.

Further, we explore operational hedging benefits *following* vertical integration. We examine the change in our firms' cost measure (cost of goods sold (COGS)) and find a drop in COGS following vertical integration. This decreased cost indicates a potential benefit. We also recognize that numerous papers suggest that firms use slack to protect against the effects of variability in internal funds or the need for costly external financing (e.g., Kim, Mauer, and Sherman, 1998; Opler, Pinkowitz, Stulz, and Williamson, 1999; Billett and Garfinkel, 2004). Since there is a cost of carrying slack, firms that reduce uncertainty should reduce their use of it. Indeed, we find that changes in slack are negatively related to vertical integration, consistent with vertical integration providing an alternative operational hedge.

Finally, if vertical integration (*VI*) is an attempt to hedge cash flow uncertainty that has recently risen, then we should observe declines in cash flow uncertainty due to *VI*. We indeed find this. Cash flow uncertainty drops significantly more (over various time-windows) when the firm vertically integrated, than when it did not.

Overall, our results suggest that risk management considerations are an important factor contributing to merger activity and particularly influence the start of merger waves. This has implications for several strands of the M&A literature. By considering uncertainty data, we directly extend the work of Mitchell and Mulherin (1996) and

[4] Froot, Scharfstein, and Stein (1993) note that hedging via derivatives is not always possible, and when possible, may be expensive. German industrial conglomerate Metallgesellschaft is a classic example of derivatives use not being risk free. Also, derivatives tend to be shorter term, creating rollover concerns and potentially higher costs for long-term exposures.

Harford (2005), which show the importance of industry shocks to merger waves. We find that cash flow uncertainty is incrementally important to the economic shocks (in their papers) that initiate merger waves. Second, we trace the influence of cash flow uncertainty shocks all the way back to individual vertical integration decisions. Given our evidence that vertical integration is an important component of waves, we explain waves as both a response to increased cash flow uncertainty and as the aggregation of this effect on individual firm merger activity.

This paper also contributes to work on vertical integration and risk management. For example, Fan (2000) studies vertical integration among petrochemical firms and links it with input cost uncertainty through detailed industry-specific analysis. But broader empirical work linking vertical integration to uncertainty is absent. Existing studies focus on single industries and this impedes our ability to generalize their conclusions. To our knowledge, we present the first empirical research to focus on vertical integration and risk management for a large panel of firm-years and the first work to connect risk management and merger waves.

Perhaps the most closely related paper to ours is Ahern and Harford (2009). They examine the role of vertical industry links in waves and show that vertical links factor in the *spread* of merger waves. However, they are silent on the nature of the economic construct that starts the wave. We show the role of risk management in waves and assert that increasing cash flow uncertainty drives the initial decision to merge vertically. Without this catalyst, we posit that waves would not propagate. Moreover, we provide the first evidence to suggest that risk management is one of the *underlying economic reasons* for the link between vertical integration and wave propagation. We are unique in connecting the intuition that vertical integration is a risk management tool to the merger wave literature.

Finally, our results complement the literature on risk management, particularly work by Froot, Scharfstein, and Stein (1993). In addition to showing the importance of risk management by highlighting the value of hedging when cash flows are uncertain, they also note the possible difficulties of using derivatives to hedge. Operational hedging via merger and particularly vertical integration is a viable alternative when hedging is valuable and derivatives are unavailable or incomplete.

The remainder of this paper is organized as follows. Section 2 describes our data and explains how we compute vertical relatedness and our measures of uncertainty. We then present our empirical results. Section 3 investigates industry merger waves and Section 4 analyzes the risk management behavior of individual firms. Overall, our research connects merger waves to individual firm operational hedging via vertical integration. Section 5 concludes the paper.

2. Data and variable construction

2.1. Mergers and merger waves

Our merger data come from Thomson Financial's SDC database. All merger or tender-offer bids from 1981 to 2006 that meet the sample selection criteria are included in the sample. To qualify for the sample, the bid must be valued at $50 million or greater in January 2002 dollars. We include only bids which involve U.S. targets and where the acquirer obtains 100% of the target shares but owned less than 50% before the announcement. The deal must be classified by SDC as either successful or unconditional. Multiple bids for one target firm within a two-month period are counted as a single bid. Bidder and target industries are classified using the Fama and French (1997) 48-industry scheme.

We use the merger waves identified by Harford (2005) for 1981–2000 and extend the wave sample through 2006 using his methodology. The methodology is as follows. Given the time series of merger bids for each industry, the highest 24-month concentration of merger bids for 2001–2006 is identified as a potential wave. To determine whether the potential wave is statistically significant, we simulate 1,000 time series of merger bids for each industry, under the assumption that each bid in the industry during the decade could occur in any month within the decade with equal probability. For each of the 1,000 simulated time series of each industry, we find the number of merger bids for the highest 24-month concentration of bids. If the actual number of bids in the potential wave is greater than the 95th percentile of the high concentration draws for that industry, the potential wave is classified as a merger wave.

2.2. Vertical integration merger sample

The existing literature presents numerous ways to identify vertical integrations. Amihud and Lev (1981) and Johnson and Houston (2000) subjectively classify each M&A event. Matsusaka (1996) uses Standard Industrial Classification (SIC) codes. Fee and Thomas (2004) note that Compustat segment disclosures report customers comprising 10% of sales and use this information to identify downstream firms. Hertzel, Li, Officer, and Rodgers (2008) follow the Fee and Thomas methodology. However, the Fee and Thomas approach excludes many upstream/downstream relationships with the 10% cutoff, and Fan and Goyal (2006) note that SIC codes are problematic.

Fan and Goyal (2006) propose an alternative measure of intra-firm relationships. They use the Input–Output (I/O) data from the Bureau of Economic Analysis (BEA)[5] to identify these relationships. They begin by building a measure of vertical relatedness between any two industries as follows. First, they calculate the amount of output required from industry i to produce one dollar's worth of industry j's output (ν_{ij}). They then calculate its corollary (amount of output required from industry j to produce one dollar of output in industry i (ν_{ji})). The vertical relatedness coefficient (V_{ij}) is the maximum of

[5] The Use Table of Benchmark Input–Output Accounts for the U.S. Economy, available every five years, through 2002.

these two metrics. It represents the opportunity for vertical integration between industries i and j. To find the V_{ij} for firms involved in a merger, the merger firms' SIC codes are used to identify the primary industry affiliations and these SIC codes are converted to Input–Output industry groups.

Following Fan and Goyal (2006) and Ahern and Harford (2009), we categorize the acquisition as a vertical integration if the vertical relatedness coefficient exceeds 1%. Our measure of vertical relatedness and our vertical integration dummy variable are both merged into our SDC and Compustat samples on the basis of SIC code and year. As the BEA tables are only reported every five years, the nearest vertical integration measure is chosen for each observation. For example, for a merger in 1986, the closest measure is the 1987 I/O Table. This is another reason why we restrict our analysis to 2006 and earlier. The latest BEA benchmark I/O tables are 2002.[6]

2.3. Uncertainty in cash flows

To assess the impact of cash flow uncertainty, we require proxies for this variable. We use two different measures of cash flow to build our uncertainty measures. Each cash flow uncertainty proxy measures whether cash flow is more volatile recently than it was in the past, and the calculations of volatility are built on 20 quarters of data. Our quarterly cash flow data are from Compustat between 1975 and 2006, and we require that these observations have non-missing values for book assets, number of shares outstanding, and stock price.

The first proxy for uncertainty is increased volatility in the Compustat operating income before depreciation (OIBD) measure. Froot, Scharfstein, and Stein (1993) emphasize variability in cash flow available to finance investment, to minimize costly external financing. To capture this effect, we focus on income uncertainty to measure risk.[7] Our second measure is increased volatility in costs of goods sold (COGS). This variable is tied closely to the industrial organization literature's intuition that vertical integration is a solution to contracting problems. An advantage to owning a supplier is that management can more accurately plan for both cost and availability of key inputs to production (Williamson, 1971). If COGS were much more volatile recently, it suggests that such planning ability is diminished in the absence of vertical integration.

All of our measures of increased uncertainty start with calculating the quarterly volatility using the prior 20 periods. They also scale by total assets (TA) to remove any undue influence from larger firms. When we report our results, we refer to cash flow uncertainty as being from either OIBD or COGS, but the scaling is always present in the calculations. The value(s) of σ are established at $t=0$.

$\sigma\left(\frac{OIBD}{TA}\right)_{-19,0}$	$=$standard deviation of (*OIBD/TA*) over quarters $t=-19$ through $t=0$ where $t=0$ is the current quarter.
$\sigma\left(\frac{COGS}{TA}\right)_{-19,0}$	$=$standard deviation of (*COGS/TA*) over quarters $t=-19$ through $t=0$ where $t=0$ is the current quarter.

Given cash flow volatilities, we create dummy variables to capture when a firm's cash flow uncertainty has recently spiked. These variables are designed to capture recent upticks in risk. They are as follows:

Rolling increase	$=1$ if three or four of the last four quarterly values of cash flow uncertainty were increasing relative to the prior quarter. For example, if the current quarter ($t=0$) is the fourth quarter of fiscal 2000, then *Rolling increase*$=1$ if σ(*OIBD/TA*) was higher in 2000:4 than in 2000:3, higher in 2000:3 than in 2000:2, higher in 2000:1 than in 1999:4, but not higher in 2000:2 than in 2000:1. An identical definition applies when *σ(COGS/TA)* is used.
5% Increase	$=1$ if the current quarter's value of σ(*OIBD/TA*) is at least 5% higher than the previous fiscal year's (same quarter) value. An identical definition applies when σ(*COGS/TA*) is used.
10% Increase	$=1$ if the current quarter's value of σ(*OIBD/TA*) is at least 10% higher than the previous fiscal year's (same quarter) value. An identical definition applies when σ(*COGS/TA*) is used.

While our measures of increased uncertainty are constructed using quarterly data, the paper's empirical analysis uses annual firm and industry data. For each firm or industry fiscal year observation, we use the uncertainty measure from the last quarter of the prior fiscal year.

A concern with these definitions of uncertainty is that they could capture a onetime change in the level of OIBD or COGS in addition to increasing uncertainty.[8] For example, assume a firm has (normalized) cash flows that vary between \$0 and \$1 over 20 quarters. Then assume the firm's cash flows jump to \$2 over each of the next four quarters. All three of our uncertainty dummies would turn "on" in this example. The question is whether uncertainty has really increased or whether the mean simply changed and cash flows are now more certain but at a higher level. Since managers might take either view, and we cannot be sure of their interpretation of this sequence of cash flows, we construct the following control variables designed to capture the sort of event described above.

Cash flow 5% increase	$=1$ if this year's cash flow measure (either *OIBD/TA* or *COGS/TA*) is at least 5% higher than last year's measure. It is zero otherwise.

[6] Ahern and Harford (2009) study merger activity through 2008. However, they use only the 1997 BEA tables. If industry links vary through time, this may lead to imprecise classification of a merger as vertically integrated.

[7] We eschew a "more complete" measure such as free cash flow to the firm (FCFF) or to equity (FCFE) for a few reasons. First, they may vary across firms and within firms across time because of variation in tax exposure. While it is possible that firms' motivations to vertically integrate could include tax strategies, this is not the logic contemplated in the theory papers cited above. Second, FCFF and FCFE may vary across firms or within firms across time because of heterogeneity in depreciation expense. Again, this is not the focus of the theoretical literature on vertical integration.

[8] We thank an anonymous referee for pointing out this concern and providing the included example.

Cash flow 5% decrease	=1 if this year's cash flow measure (either *OIBD/TA* or *COGS/TA*) is at least 5% lower than last year's measure. It is zero otherwise.

Adding these controls separates a level shock from a change in uncertainty. With these variables, we can refine the interpretation of our uncertainty/risk management results and distinguish between whether cash flow uncertainty by itself encourages merger (and vertical integration) activity, or whether uncertainty is a manifestation of a shock that causes the merger activity. By controlling for cash flow shocks, the coefficients on our uncertainty variables are more likely to measure the effect of uncertainty *not caused by a levels shock* on merger activity.

2.4. Other control variables

It is imperative that we control for previously documented determinants of merger activity, particularly waves. Harford (2005) develops an "economic shock index"—the first principal component from seven economic shock variables—to indicate the magnitude of industry shocks. Each economic shock variable is measured as the median absolute change in the underlying economic variable, per industry year. The economic variables are: net income scaled by sales, asset turnover, research and development (R&D) over assets, capital expenditures over assets, employee growth, return on assets (ROA), and sales growth. The index is measured in year $t-1$. We construct Harford's industry economic shock index for our sample and include it in our empirical analysis.

To exclude the possibility that behavioral factors explain our results, we include the same behavioral variables that are found in Harford (2005). These are the industry median values of market-to-book and three-year return, and the intra-industry standard deviation of three-year returns. These variables are measured at $t-1$. Including these controls allows us to measure the incremental importance of uncertainty and risk management incentives to merger waves, beyond the behavioral literature's results.

Deregulation events also are examined as possible determinants of merger waves. We include Harford's deregulation event-based dummy, updated using the latest edition of Viscusi et al.'s (2005) *Economics of Regulation and Antitrust*. The dummy equals one in years that were preceded by a major deregulatory event.

Harford (2005) highlights the importance of market liquidity to the relationship between industry shocks and merger waves. We control for market liquidity with the Baa rate spread relative to the Federal Funds rate (*Spread*). We use the prior year's December average spread.

Finally, we construct a set of firm-specific control variables common to the literature on mergers and acquisitions. All of them are measured at year $t-1$.

Ln(*Assets*):	The natural log of total assets.
COGS/TA:	Cost of goods sold, scaled by total assets.
OIBD/TA:	Operating income before depreciation, scaled by total assets.

Table 1
Descriptive statistics.
The sample includes all Compustat firms with relevant annual data from 1981 to 2006. Control variables are defined in the table using Compustat acronyms. For any observation, *Deregulation indicator* equals one for deregulation periods, identified by Viscusi et al. (2005). *Spread* is the difference between the Baa rate and the Fed Funds rate. The *3 Yr return* and σ(*3 Yr return*) are the industry-year median buy-and-hold return and the standard deviation of that return. *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. *M&A indicator* equals one if a merger or acquisition occurred in that year. *Vertical coefficient factor* is calculated from the BEA I/O tables and *Vertical integration indicator* equals one if *Vertical coefficient factor* is greater than 1% (following Fan and Goyal, 2006). Uncertainty is measured as increases in either *COGS/TA* volatility or *OIBD/TA* volatility, where volatility is measured using 20 prior quarters of data and an increase is defined as increases in volatility for at least three of the prior four quarters (*Rolling increase*), or a 5% or 10% increase in volatility from the prior year-end quarterly measure.

All observations	Obs.	Mean	Median	Std. dev.
LnTA ln(*Compustat: AT*)	154,803	4.79	4.74	2.61
M/B ((*DLTT*+*DLC*+*PSTK*+*CSHO*$*$*PRCC_F*)/*AT*)	151,037	7.87	1.03	796.24
Leverage ((*DLTT*+*DLC*)/*AT*)	154,512	0.57	0.21	14.67
Cash/TA (*CHE/AT*)	154,727	0.16	0.07	0.21
Sales/TA (*SALE/AT*)	154,522	1.10	0.90	2.72
COGS/TA (*COGS/AT*)	154,518	0.83	0.55	5.49
OIBD/TA (*OIBDP/AT*)	153,994	−0.51	0.09	63.15
Deregulation indicator	155,021	0.03	0.00	0.02
Spread (%)	155,021	0.03	0.04	0.01
3 Yr return	149,411	0.18	0.12	0.50
σ(*3 Yr return*)	147,790	1.21	0.80	1.52
Economic shock factor	154,294	−0.12	−0.31	0.78
M&A indicator	154,952	0.05	0.00	0.22
Vertical integration indicator—all firms	154,952	0.03	0.00	0.17
Vertical integration indicator—within M&A	8,000	0.55	1.00	0.50
Vertical coefficient factor	8,000	0.03	0.02	0.06
OIBD volatility rolling increase indicator	62,344	0.34	0.00	0.47
OIBD volatility 5% increase indicator	59,971	0.32	0.00	0.47
OIBD volatility 10% increase indicator	59,971	0.23	0.00	0.42
COGS volatility rolling increase indicator	86,774	0.36	0.00	0.48
COGS volatility 5% increase indicator	83,284	0.35	0.00	0.48
COGS volatility 10% increase indicator	83,284	0.27	0.00	0.44

B/M: Book-to-market ratio.
Leverage: Long-term debt plus current portion of long-term debt, all scaled by total assets.
Cash/TA: Cash plus marketable securities (or slack), scaled by total assets.
Sales/TA: Revenues scaled by total assets.

2.5. Summary statistics

Summary statistics for the full sample are presented in Table 1. This sample includes all Compustat firms with relevant annual data from 1981 to 2006. Since some firm data are available with greater regularity, the sample size differs across variables. Of the full sample of firm/years, only about 5% show a merger or acquisition. Within the sample of mergers, the average vertical coefficient factor is 3%. Slightly over half (55%) of the mergers in our sample qualify as carrying an important component (at least 1%) of vertical integration. These proportions are in line with those reported in Ahern and Harford (2009).

Our increased uncertainty dummies show interesting patterns. First, on average, it appears that (very) roughly 30% of our firm/year observations exhibit spikes in cash flow uncertainty. For the rolling measures and the 5% increase measures, roughly a third of our observations show spikes. For the 10% increase measure, only about a quarter of the observations show spikes.

Finally, Table 1 shows that our full sample resembles Compustat firms in two important characteristics: they tend to be small, on average, with total assets of roughly $120 million, and they also tend to be growth firms with M/B ratios above 1.0. Untabulated results indicate some differences between firm-year observations in which a merger occurred, and non-merger observations, as well as between firm-year observations with a vertical integration merger versus other merger. However, we control for all of the above-listed firm characteristics in our multivariate tests, and we use fixed effects, random effects, and sample selection models to address econometric concerns with such differences. We discuss this in the results section.

3. Evidence of risk management from industry merger waves

More M&A activity occurs during economic "boom" periods (Lambrecht, 2004; Rhodes-Kropf, Robinson, and Viswanathan, 2005; Bouwman, Fuller, and Nain, 2009). The literature oscillates between behavioral and economic shock explanations for these merger waves. Behavioral explanations cite stock market misvaluations (Shleifer and Vishny, 2003; Rhodes-Kropf, Robinson, and Viswanathan (2005)), managerial herding (Bouwman, Fuller, and Nain, 2009), and envious CEOs (Goel and Thakor, 2010). The contrasting (neoclassical) view is that economic shocks encourage firms to merge as a mechanism for reallocating assets optimally. Mitchell and Mulherin (1996), Harford (2005), and Ovtchinnikov (2010) find that shocks in the form of deregulation or innovation explain merger clustering. Harford (2005) also shows that prior behavioral evidence may be reinterpreted as consistent with the importance of overall capital liquidity.

3.1. The importance of vertical integration in merger waves

Our research builds on the above work by considering risk management *through vertical integration* as a key driver of merger waves. We begin our results by documenting the role of vertical integration activity in merger waves. First, we highlight the preponderance (or role) of vertical integration in merger waves. To date, there is limited empirical work differentiating among merger types to explain the incidence of merger waves. Table 2 presents the annual-industry means for the number of acquisitions, the number of vertical integrations, and the ratio of vertical integrations to all mergers, segmented by whether the industry-year was part of an industry merger wave or not. Merger wave years are associated (by design) with a higher average number of acquisitions (14.55) per industry-year than non-wave years (5.83). We also see more vertical integrations per industry-year in merger waves (7.96) than during non-waves (3.18). More interestingly, the fraction of mergers in an industry-year that are vertically integrated is higher (0.45) during waves than during non-waves (0.33). As the difference between these is statistically significant and economically large, vertical integration activity appears to be a more important component of merger activity during waves.

Thus far, our evidence is consistent with the inferences from Ahern and Harford (2009) that vertical integration plays a role in merger waves. However, our view of the role of vertical integration differs from theirs. They argue that vertical integration links with merger waves because of inter- and intra-industry links. For example, the product market relationship between radio stations

Table 2
Merger type heterogeneity.
Summary statistics are presented for the level of vertical integration and M&A activity from 1981 through 2006. We use the merger waves identified by Harford (2005) for 1981–2000 and extend the wave sample through 2006 using his methodology. For any observation, *M&A indicator* equals one if a merger or acquisition occurred in that year. *Vertical integration indicator* equals one if *Vertical coefficient factor*, calculated from the BEA I/O Tables, is greater than 1% (following Fan and Goyal, 2006). The *VI/MA* ratio is calculated on an industry-year basis.

	Merger wave periods			Non-wave periods			Difference in means
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	*t*-statistic
# VI	120	7.958	17.573	1,176	3.176	8.754	2.944
# M&A	120	14.550	21.910	1,176	5.828	11.119	4.304
VI/M&A	120	0.447	0.352	1,176	0.334	0.364	3.338

Table 3
Vertical integrations in merger waves.

Logit models with industry fixed or random effects relate the level of vertical integration activity to merger waves. The sample is 48 industries observed annually from 1980 through 2006. The dependent variable equals unity if a merger waves exists in that industry-year. The explanatory variables are measured at the end of year $t-1$. *VI/MA* is the percentage of M&A events that are vertical integrations. *B/M* is the industry median book-to-market ratio. The *3 Yr return* and σ(*3 Yr return*) are the industry-year median buy-and-hold return and the standard deviation of that return. *Spread* is the difference between the Baa rate and the Fed Funds rate. *Dereg indicator* is an indicator variable for deregulation periods, identified by Viscusi et al. (2005). *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. Numbers below each coefficient are *p*-values.

	Dependent variable: merger wave indicator							
	Fixed effects				Random effects			
VI/MA	0.831	0.600	0.774	0.644	0.874	0.646	0.854	0.702
	(0.009)	(0.070)	(0.017)	(0.051)	(0.003)	(0.036)	(0.005)	(0.024)
B/M_{t-1}		0.063		−0.015		−0.133		−0.167
		(0.851)		(0.968)		(0.592)		(0.580)
3 Yr return$_{t-1}$		−0.862		−0.787		−0.845		−0.762
		(0.001)		(0.002)		(0.001)		(0.002)
σ(*3 Yr return*)$_{t-1}$		0.104		0.123		0.118		0.126
		(0.185)		(0.118)		(0.131)		(0.111)
Spread$_{t-1}$			−0.153	−0.159			−0.162	−0.167
			(0.016)	(0.021)			(0.011)	(0.015)
Dereg indicator$_{t-1}$			−0.821	−0.570			−0.518	−0.249
			(0.352)	(0.529)			(0.568)	(0.789)
Econ shock factor$_{t-1}$			0.299	0.275			0.266	0.191
			(0.061)	(0.099)			(0.049)	(0.181)
Constant					−3.008	−2.804	−2.473	−2.336
					(0.000)	(0.000)	(0.000)	(0.000)
# Observations	810	744	780	744	1,296	1,186	1,248	1,186
# Industries	30	30	30	30	48	48	48	48

and the record industry may encourage consolidation in the latter when the former consolidates to create less diverse playlists. By contrast, we emphasize the role of risk management. If cash flows become more volatile, firms experiencing this may seek to reduce that volatility through vertical integration. In the context of the above example, we contemplate the radio station firm may buy the record industry firm because this reduces the volatility of input costs. This view is in line with that studied empirically by Fan (2000), but on a much broader scale.

Since summary statistics can be misleading, we confirm the importance of vertical integration to merger waves in Table 3. We estimate logit models (separately) with fixed and random industry effects to predict whether the industry/year is part of a merger wave or not. Our logits include control variables common to the literature on merger waves, such as credit risk spread, the median annual book-to-market for the industry, the Harford (2005) industry economic shock factor, the deregulation indicator, and the three-year industry return and its standard deviation. The variable of interest is the ratio of the number of vertical integrations to mergers (*VI*/*MA*) in that industry/year. A positive coefficient on *VI*/*MA* indicates that the proportion of vertical integration activity in that industry/year is positively associated with the likelihood that the industry-year is part of an industry merger wave.

Across all eight specifications, the coefficient on *VI*/*MA* is significantly positive. In the first specification (fixed effects with no controls), the coefficient on *VI*/*MA* is 0.831, significant at the 1% level.[9] When vertical integration activity represents a larger proportion of all merger activity in an industry/year, that industry/year is more likely to be part of an industry merger wave. We confirm this result in the second specification (still using fixed effects), but now including the typical behavioral controls found in the merger wave literature. The coefficient on *VI*/*MA* is still significantly positive. In the third specification, we control for the typical neoclassical economic variables in the extant wave literature. We continue to find a significantly positive relation between *VI*/*MA* and the merger wave indicator (dependent variable). Finally, in specification four (the last of the fixed effects logits), we control for both behavioral and neoclassical economic variables, and show a significantly positive relation between *VI*/*MA* and merger waves. The level of vertical integration activity within an industry/year is incrementally important beyond the usual wave determinants.

The neoclassical economic control variables largely carry expected signs and significance. The coefficient on spread is significantly negative (tighter liquidity conditions inhibit the start of a merger wave). The coefficient on the economic shock index of Harford is significantly positive—economic shocks encourage the start of merger waves.

[9] The coefficient does not directly measure the effect of a unit change in VI/MA on merger wave likelihood. For that, we calculate marginal effects. Our discussion of the economic significance of uncertainty on merger activity focuses on these marginal effects. See Sections 3.2 and 3.3 below.

Because the fixed effects approach excludes industries that did not experience a wave, the next four specifications replicate the first four (respectively) using random effects. The results are remarkably similar. We therefore rely on random effects in our later tests (using industry-level data) to avoid dropping these observations. Regardless of the estimation technique, the results in Table 3 imply that the degree of vertical integration activity is a salient factor in understanding merger waves. The next logical question is what causes so many firms to vertically integrate and thus constitute a wave.

3.2. The importance of cash flow uncertainty to merger waves

To understand the relationship between risk management and waves, we directly link increased cash flow uncertainty with merger wave starts. We then show that individual firms respond to cash flow uncertainty by vertically integrating, leading to more vertical integration in industries where more firms experienced higher uncertainty. Given the link between vertical integration activity and waves in Table 3, this supports our inference that risk management is an important part of merger waves.

Table 4 presents the coefficients from a model predicting the start of a merger wave estimated using a logit with industry random effects. The dependent variable equals one in the industry/year that represents the start of an industry merger wave. The key independent variable is a measure to capture increased cash flow uncertainty, but since we are explaining aggregate merger activity (a wave), we *count* the number of firms in that industry/year that experienced an increase in cash flow uncertainty.[10]

Like Table 3, we include both neoclassical and behavioral control variables common to the literature on merger waves. However, we require a few additional controls to ensure that we are measuring the influence of risk management incentives on the start of merger waves. First, we control for the number of firms in each industry. It is possible that more firms in an industry can associate with a larger number of firms experiencing a spike in cash flow uncertainty. If a large number of firms in the industry also associates with a higher likelihood of merger waves, then we must control for the number of firms in an industry. Second, we also control for the number of firms that experience a 5% (either direction) change in cash flow *level* since the prior fiscal year. This is designed to control for cases where cash flow might change once and then level off. If this happens to trigger our uncertainty variables, we wish to control for it in our logit so that we do not assign explanatory power inappropriately.

There are two panels in Table 4, the first uses *OIBD/TA* to build our cash flow uncertainty and cash flow level shock variables and Panel B uses *COGS/TA*. Within each panel, there are 12 specifications. The 12 models are broken into three groups, one for each of the increased cash flow uncertainty dummies: rolling, 5% increase, and 10% increase, respectively. Within each group (rolling, 5%, 10%), there are four specifications. The first and second only control for extant merger wave literature variables with the second excluding all industries in the top decile of "number of firms" in the industry. The exclusion of the largest industries is a blunt control for the possibility that a large number of firms in an industry may lead to a larger number of firms experiencing cash flow uncertainty increases. The third specification actually includes the number of firms in the industry as a control variable. The fourth model also includes the control for number of firms experiencing a 5% shock (either direction) in cash flow level. Given that specifications 4, 8, and 12 have all the controls, we focus our discussion on them even though our other specifications offer similar results and inferences.

In Panel A, all specifications show a positive coefficient on our variable of interest, *Increased uncertainty*. The more firms with increased cash flow uncertainty, the more likely an industry merger wave will start in the next year. Since the increased uncertainty measures are consistently significant, risk management considerations appear to contribute to the *start* of merger waves. Again, this view is different from Ahern and Harford's (2009) view of the role of vertical integration in merger waves. While we highlight the economic shock that precipitates the waves, they study the role of vertical integration in propagating the wave. An understanding of the dual role of vertical integration in merger waves is important. It is also noteworthy that the coefficients on some of the cash flow level shocks (5% decreases) are significant. Changes in the level of cash flows appear to be relevant. Industry size appears to be negatively related to merger wave start likelihood when all control variables are included.

We also note that our control for ex-ante median industry three-year returns is a significant, *but negative*, determinant of merger waves. Why might higher industry returns discourage the start of waves? Our view is related to our theses that classical economic effects, and particularly shocks and uncertainty, are important components of merger decisions. We hypothesize that higher three-year returns occur in industries that are more optimally organized and fully utilizing their assets. Controlling for any economic shocks or increases to uncertainty (which we do) that typically move these industries away from their optimum, these high performers are in the least need of a merger wave to reallocate assets.

Economically, the influence of risk management incentives on merger wave starts appears important. We compute marginal effects at the mean of the explanatory variables for each of the full-model specifications (columns 4, 8, and 12 for both Panels A and B). For a one-standard-deviation change in our uncertainty variable, there is a 0.56–0.68% increase in the likelihood of a merger wave start. Relative to an unconditional probability of 3.24% for a merger wave start in any industry-year,[11] this is an economically important factor. It is also useful to compare this effect with those of

[10] The distribution (across industry-years) of the number of firms experiencing a spike in cash flow uncertainty is highly skewed. We take logs of (1+ the number of these firms) to normalize, but we refer (in the text and tables) to this construct as "*Increased uncertainty*."

[11] There are 42 industry merger wave starts in our sample. Given 1,296 industry-years in the sample, the unconditional probability of a merger wave start in any industry-year is 3.24%.

Table 4
Uncertainty and merger waves.

Logit models with industry random effects are used to predict industry merger waves. The sample is 48 industries observed annually from 1981 through 2006. The dependent variable equals unity if an industry starts a merger wave during that year. The explanatory variables are measured at the end of year $t-1$. *Increased uncertainty* is the number of firms, transformed by the natural log, experiencing increased firm-level uncertainty for an industry-year. Uncertainty is measured as increases in either *COGS/TA* volatility or *OIBD/TA* volatility, where volatility is measured using 20 prior quarters of data and an increase is defined as increases in volatility for at least three of the prior four quarters (*Rolling increase*), or a 5% or 10% increase in volatility from the prior year-end quarterly measure. *Industry size* is the number of firms in an industry-year. *Shock, 5% increase (decrease)* is the number of firms in an industry-year experiencing a 5% increase (decrease) to OIBD (Panel A) or COGS (Panel B). *B/M* is the industry median book-to-market ratio. The *3 Yr return* and σ(*3 Yr return*) are the industry-year median buy-and-hold return and the standard deviation of that return. *Spread* is the difference between the Baa rate and the Fed Funds rate. *Dereg indicator* is an indicator variable for deregulation periods, identified by Viscusi et al. (2005). *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. Numbers below each coefficient are *p*-values.

Panel A: OIBD volatility	Dependent variable: merger wave start indicator											
Uncertainty measure	Rolling increase				5% Increase				10% Increase			
Increased uncertainty$_{t-1}$	0.484	0.624	0.855	0.820	0.512	0.639	0.868	0.834	0.536	0.664	0.846	0.783
	(0.002)	(0.005)	(0.005)	(0.010)	(0.001)	(0.003)	(0.003)	(0.006)	(0.001)	(0.002)	(0.003)	(0.008)
Industry size$_{t-1}$			−0.006	−0.013			−0.005	−0.013			−0.005	−0.012
			(0.158)	(0.018)			(0.147)	(0.015)			(0.175)	(0.020)
OIBD shock, 5% increase$_{t-1}$				−0.002				−0.002				−0.002
				(0.725)				(0.742)				(0.743)
OIBD shock, 5% decrease$_{t-1}$				0.011				0.011				0.010
				(0.084)				(0.091)				(0.101)
B/M$_{t-1}$	−0.441	−0.284	−0.416	−0.276	−0.412	−0.260	−0.384	−0.263	−0.396	−0.261	−0.382	−0.275
	(0.416)	(0.598)	(0.439)	(0.595)	(0.447)	(0.620)	(0.473)	(0.608)	(0.463)	(0.617)	(0.474)	(0.593)
3 Yr return$_{t-1}$	−1.152	−1.105	−1.131	−1.308	−1.135	−1.074	−1.112	−1.286	−1.120	−1.042	−1.092	−1.274
	(0.005)	(0.014)	(0.005)	(0.002)	(0.005)	(0.017)	(0.006)	(0.003)	(0.006)	(0.020)	(0.007)	(0.003)
σ(*3 Yr return*)$_{t-1}$	0.099	0.150	0.097	0.128	0.099	0.148	0.101	0.130	0.099	0.148	0.101	0.131
	(0.355)	(0.178)	(0.380)	(0.240)	(0.354)	(0.185)	(0.360)	(0.230)	(0.355)	(0.184)	(0.355)	(0.222)
Spread$_{t-1}$	−0.255	−0.258	−0.260	−0.249	−0.263	−0.265	−0.267	−0.257	−0.263	−0.266	−0.265	−0.253
	(0.027)	(0.050)	(0.026)	(0.042)	(0.024)	(0.046)	(0.024)	(0.038)	(0.024)	(0.046)	(0.025)	(0.040)
Dereg indicator$_{t-1}$	1.351	1.136	1.435	1.511	1.396	1.265	1.540	1.648	1.427	1.259	1.565	1.664
	(0.236)	(0.490)	(0.207)	(0.201)	(0.222)	(0.445)	(0.179)	(0.165)	(0.213)	(0.450)	(0.174)	(0.162)
Econ shock factor$_{t-1}$	0.151	0.146	0.155	0.178	0.164	0.154	0.167	0.189	0.164	0.149	0.163	0.179
	(0.362)	(0.429)	(0.362)	(0.303)	(0.322)	(0.400)	(0.323)	(0.269)	(0.320)	(0.412)	(0.329)	(0.289)
Constant	−3.535	−4.012	−4.036	−4.253	−3.568	−4.004	−4.031	−4.234	−3.480	−3.879	−3.793	−3.957
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
# Observations	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186
# Industries	48	43	48	48	48	43	48	48	48	43	48	48
Exclude largest industries	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No

Panel B: COGS volatility	Dependent variable: merger wave start indicator											
Uncertainty measure	Rolling increase				5% Increase				10% Increase			
Increased uncertainty$_{t-1}$	0.486	0.611	0.759	0.830	0.495	0.586	0.738	0.768	0.477	0.536	0.663	0.670
	(0.003)	(0.005)	(0.011)	(0.012)	(0.003)	(0.006)	(0.011)	(0.013)	(0.004)	(0.011)	(0.015)	(0.021)
Industry size$_{t-1}$			−0.004	−0.014			−0.004	−0.013			−0.003	−0.012
			(0.270)	(0.014)			(0.296)	(0.016)			(0.390)	(0.021)
COGS shock, 5% increase$_{t-1}$				0.012				0.011				0.011
				(0.002)				(0.002)				(0.002)
COGS shock, 5% decrease$_{t-1}$				−0.002				−0.002				−0.002
				(0.591)				(0.619)				(0.657)

Table 4 (*continued*)

Panel B: COGS volatility

	Dependent variable: merger wave start indicator											
Uncertainty measure	Rolling increase				5% Increase				10% Increase			
B/M_{t-1}	−0.457	−0.304	−0.450	−0.320	−0.454	−0.306	−0.449	−0.323	−0.459	−0.328	−0.460	−0.338
	(0.398)	(0.575)	(0.402)	(0.552)	(0.405)	(0.576)	(0.407)	(0.552)	(0.398)	(0.551)	(0.394)	(0.533)
3 Yr return$_{t-1}$	−1.164	−1.107	−1.163	−1.361	−1.153	−1.095	−1.148	−1.356	−1.164	−1.111	−1.162	−1.378
	(0.004)	(0.014)	(0.004)	(0.002)	(0.005)	(0.015)	(0.005)	(0.002)	(0.004)	(0.014)	(0.004)	(0.001)
σ(*3 Yr return*)$_{t-1}$	0.099	0.151	0.101	0.132	0.098	0.150	0.101	0.135	0.101	0.156	0.104	0.143
	(0.351)	(0.174)	(0.348)	(0.226)	(0.352)	(0.175)	(0.346)	(0.211)	(0.343)	(0.159)	(0.332)	(0.187)
Spread$_{t-1}$	−0.262	−0.262	−0.264	−0.221	−0.265	−0.259	−0.266	−0.220	−0.260	−0.253	−0.260	−0.212
	(0.023)	(0.047)	(0.023)	(0.076)	(0.022)	(0.048)	(0.022)	(0.077)	(0.025)	(0.053)	(0.025)	(0.086)
Dereg indicator$_{t-1}$	1.613	1.411	1.806	2.113	1.618	1.418	1.796	2.114	1.673	1.484	1.835	2.162
	(0.153)	(0.386)	(0.112)	(0.070)	(0.152)	(0.385)	(0.114)	(0.070)	(0.139)	(0.362)	(0.108)	(0.063)
Econ shock factor$_{t-1}$	0.163	0.157	0.166	0.214	0.167	0.149	0.168	0.208	0.161	0.133	0.162	0.196
	(0.335)	(0.403)	(0.336)	(0.222)	(0.324)	(0.428)	(0.330)	(0.234)	(0.338)	(0.474)	(0.342)	(0.255)
Constant	−3.714	−4.235	−4.198	−4.663	−3.697	−4.136	−4.109	−4.494	−3.537	−3.876	−3.798	−4.145
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
# Observations	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186
# Industries	48	43	48	48	48	43	48	48	48	43	48	48
Exclude largest industries	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No

other variables shown to influence merger activity in the extant literature. Our estimates indicate that a one-standard-deviation change in Harford's economic shock factor increases the likelihood of merger wave start by between 0.25% and 0.28%. This is less than one-half the economic effect of increased uncertainty and the coefficient is not statistically significant. Further, many of the other previously identified wave determinants, such as deregulation, the standard deviation of three-year returns, and book-to-market have statistically insignificant marginal effects.

On the other hand, some variables show either comparable or larger economic effects on the likelihood of a merger wave start. A one-standard-deviation change in three-year returns decreases the likelihood of a wave by 1.15–1.19%, more than twice the impact of increased uncertainty. A one-standard-deviation change in credit spreads leads to between a 0.53% and 0.64% decrease in the likelihood of a wave. This impact is similar to the magnitude of increased uncertainty's influence.

Finally, both negative OIBD 5% shocks and positive COGS 5% shocks increase the likelihood of a wave slightly (0.03% for a one-standard-deviation change in the OIBD level shock, and 0.02% for a COGS level shock). This suggests that large drops in operating income or jumps in costs have an economically small but statistically significant impact on wave starts. Taken together, the above discussed economic sensitivities suggest that risk management incentives driven by increased uncertainty have a material economic effect on merger wave starts.

3.3. *Industry aggregate merger activity*

Having shown that cash flow uncertainty matters for the incidence of merger waves, we expand our analysis to ask whether uncertainty explains the preponderance of vertically related mergers in all periods and industries. Prior work linking risk management with vertical integration has been industry-specific. We do not focus on one industry; we study all industries. This inquiry is important because it allows us to assess whether risk management is a motivation for vertical integration in general. We expect that increases in cash flow uncertainty increase the propensity to vertically integrate in many industries and that waves represent the aggregation of this. Thus, documenting the more widespread relationship between uncertainty and vertical integration facilitates generalizing our risk management hypothesis.

Table 5 presents double-sided Tobit estimates (with industry random effects)[12] to examine the proportion of vertically related mergers within an industry/year. The format replicates that in Table 4, with two panels defined by the cash flow volatility measure used, and 12 specifications per panel. Only the dependent variable is changed. As the *Increased uncertainty* coefficients are uniformly

[12] While the Tobit model accommodates the dependent variable being bounded on (0,1), it cannot be combined with industry fixed effects (Greene, 2004). However, estimating the model with ordinary least squares (OLS) and industry fixed effects generates similar results.

Table 5
Vertical integration behavior following uncertainty.

Tobit models with industry random effects are used to estimate whether the level of uncertainty affects the amount of vertical integration activity in an industry-year. The sample is 48 industries observed annually from 1981 through 2006. The dependent variable is the percentage of mergers and acquisitions in an industry-year that are vertical integrations. The explanatory variables are measured at the end of year $t-1$. *Increased uncertainty* is the number of firms experiencing increased firm-level uncertainty for an industry-year, transformed by the natural log. Uncertainty is measured as increases in either *COGS/TA* volatility or *OIBD/TA* volatility, where volatility is measured using 20 prior quarters of data and an increase is defined as increases in volatility for at least three of the prior four quarters (*Rolling increase*), or a 5% or 10% increase in volatility from the prior year-end quarterly measure. *Shock, 5% increase (decrease)* is the number of firms in an industry-year experiencing a 5% increase (decrease) to either OIBD (Panel A) or COGS (Panel B). *B/M* is the industry median book-to-market ratio. The *3 Yr return* and *σ(3 Yr return)* are the industry-year median buy-and-hold return and the standard deviation of that return. *Spread* is the difference between the Baa rate and the Fed Funds rate. *Dereg indicator* is an indicator variable for deregulation periods, identified by Viscusi et al. (2005). *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. Numbers below each coefficient are *p*-values.

Panel A: OIBD volatility	Dependent variable: *VI/M_A*											
Uncertainty measure	Rolling increase				5% Increase				10% Increase			
Increased uncertainty$_{t-1}$	0.162	0.203	0.177	0.174	0.151	0.190	0.154	0.151	0.162	0.196	0.166	0.163
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry size$_{t-1}$			−0.000	−0.000			−0.000	−0.000			−0.000	−0.000
			(0.562)	(0.486)			(0.919)	(0.782)			(0.854)	(0.789)
OIBD/COGS shock, 5% increase$_{t-1}$				−0.000				−0.000				−0.000
				(0.677)				(0.736)				(0.734)
OIBD/COGS shock, 5% decrease$_{t-1}$				0.001				0.001				0.000
				(0.457)				(0.522)				(0.593)
B/M$_{t-1}$	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.007	−0.006	−0.007	−0.007
	(0.182)	(0.236)	(0.184)	(0.179)	(0.165)	(0.215)	(0.165)	(0.161)	(0.155)	(0.202)	(0.155)	(0.152)
3 Yr return$_{t-1}$	−0.039	−0.064	−0.040	−0.041	−0.030	−0.053	−0.030	−0.031	−0.027	−0.050	−0.027	−0.028
	(0.328)	(0.173)	(0.314)	(0.306)	(0.450)	(0.255)	(0.449)	(0.438)	(0.503)	(0.287)	(0.501)	(0.487)
σ(3 Yr return) $_{t-1}$	0.006	0.015	0.007	0.007	0.006	0.015	0.007	0.007	0.007	0.017	0.007	0.008
	(0.743)	(0.522)	(0.711)	(0.690)	(0.726)	(0.521)	(0.721)	(0.702)	(0.698)	(0.473)	(0.687)	(0.672)
Spread$_{t-1}$	0.001	0.008	0.002	0.002	0.001	0.007	0.001	0.001	0.001	0.008	0.001	0.001
	(0.907)	(0.597)	(0.898)	(0.875)	(0.951)	(0.626)	(0.951)	(0.927)	(0.963)	(0.610)	(0.960)	(0.941)
Dereg indicator$_{t-1}$	0.031	−0.099	0.035	0.036	0.053	−0.060	0.054	0.054	0.064	−0.051	0.067	0.067
	(0.877)	(0.727)	(0.861)	(0.857)	(0.792)	(0.832)	(0.788)	(0.786)	(0.746)	(0.856)	(0.738)	(0.736)
Econ shock factor$_{t-1}$	−0.039	−0.030	−0.040	−0.040	−0.039	−0.029	−0.039	−0.039	−0.040	−0.031	−0.040	−0.040
	(0.198)	(0.377)	(0.188)	(0.188)	(0.198)	(0.390)	(0.197)	(0.196)	(0.186)	(0.353)	(0.183)	(0.182)
Constant	−0.146	−0.269	−0.160	−0.166	−0.111	−0.232	−0.113	−0.117	−0.087	−0.192	−0.089	−0.093
	(0.057)	(0.002)	(0.047)	(0.041)	(0.137)	(0.007)	(0.142)	(0.129)	(0.222)	(0.021)	(0.217)	(0.204)
# Observations	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186
# Industries	48	43	48	48	48	43	48	48	48	43	48	48
Exclude largest industries	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No

Panel B: COGS volatility	Dependent variable: *VI/M_A*											
Uncertainty measure	Rolling increase				5% Increase				10% Increase			
Increased uncertainty$_{t-1}$	0.163	0.206	0.173	0.172	0.177	0.225	0.196	0.196	0.169	0.209	0.179	0.179
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry size$_{t-1}$			−0.000	−0.000			−0.000	−0.000			−0.000	−0.000
			(0.722)	(0.612)			(0.424)	(0.524)			(0.678)	(0.719)
OIBD/COGS shock, 5% increase$_{t-1}$				0.001				0.001				0.001
				(0.261)				(0.373)				(0.334)
OIBD/COGS shock, 5% decrease$_{t-1}$				−0.000				−0.001				−0.001
				(0.509)				(0.366)				(0.360)

Table 5 (*continued*)

Panel B: COGS volatility

	Dependent variable: *VI/M_A*											
Uncertainty measure	Rolling increase				5% Increase				10% Increase			
B/M_{t-1}	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007
	(0.140)	(0.177)	(0.139)	(0.145)	(0.118)	(0.147)	(0.114)	(0.121)	(0.125)	(0.161)	(0.123)	(0.131)
3 Yr return$_{t-1}$	−0.035	−0.058	−0.036	−0.037	−0.021	−0.043	−0.021	−0.023	−0.025	−0.048	−0.025	−0.027
	(0.371)	(0.213)	(0.364)	(0.352)	(0.598)	(0.358)	(0.594)	(0.565)	(0.531)	(0.303)	(0.527)	(0.501)
σ(*3 Yr return*)$_{t-1}$	0.003	0.014	0.003	0.007	0.001	0.011	0.002	0.005	0.002	0.013	0.002	0.006
	(0.865)	(0.556)	(0.851)	(0.713)	(0.965)	(0.625)	(0.932)	(0.782)	(0.928)	(0.577)	(0.911)	(0.756)
Spread$_{t-1}$	0.000	0.006	0.000	0.002	−0.004	0.002	−0.005	−0.003	−0.002	0.005	−0.002	−0.000
	(0.983)	(0.694)	(0.982)	(0.869)	(0.734)	(0.905)	(0.724)	(0.825)	(0.886)	(0.736)	(0.886)	(0.996)
Dereg indicator$_{t-1}$	0.072	−0.054	0.077	0.092	0.061	−0.068	0.071	0.087	0.082	−0.038	0.089	0.105
	(0.717)	(0.850)	(0.699)	(0.646)	(0.757)	(0.809)	(0.720)	(0.662)	(0.678)	(0.895)	(0.657)	(0.599)
Econ shock factor$_{t-1}$	−0.033	−0.022	−0.033	−0.032	−0.027	−0.015	−0.028	−0.027	−0.030	−0.020	−0.031	−0.030
	(0.281)	(0.512)	(0.278)	(0.285)	(0.363)	(0.652)	(0.357)	(0.364)	(0.315)	(0.546)	(0.312)	(0.319)
Constant	−0.212	−0.361	−0.225	−0.238	−0.217	−0.378	−0.240	−0.251	−0.164	−0.299	−0.173	−0.185
	(0.012)	(0.000)	(0.014)	(0.010)	(0.007)	(0.000)	(0.005)	(0.004)	(0.034)	(0.001)	(0.032)	(0.023)
# Observations	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186	1,186	1,056	1,186	1,186
# Industries	48	43	48	48	48	43	48	48	48	43	48	48
Exclude largest industries	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No

positive and statistically significant at the 1% level, the results indicate that rising cash flow uncertainty raises the proportion of merger activity that is vertically related. Again, this is consistent with the notion that vertical integration is a potential operational hedge to increased cash flow uncertainty. Notably, the economic shock factor and shocks to the level of cash flows have no influence on the preponderance of vertical integration in merger activity. Shocks may encourage merger activity (Harford, 2005; Mitchell and Mulherin, 1996), but there is no theoretical reason for them to encourage vertical integration (unless the shock leads to increased cash flow uncertainty).

Again we assess the economic import of our estimated coefficients, calculating marginal effects at the means of explanatory variables. A one-standard-deviation change in increased uncertainty increases the level of vertical integration activity (scaled by all M&A) by 3.67–4.88%. None of the other variables' marginal effects are of similar magnitude. This is hardly unexpected as those variables were expected to predict merger waves—not the preference to vertically integrate.

Finally, in unreported results, we confirm that the number of firms experiencing increased uncertainty predicts the level of vertical integration activity even when the wave periods are excluded. In general, cash flow uncertainty is an important component of an industry's vertical integration activity. Prior research (Fan, 2000) illustrates a specific case of this (in the petrochemical industry). However, we show this phenomenon occurs across many industries, thereby highlighting how risk management considerations are widespread in the incidence of vertical integration activity.

3.4. An alternative view of increased uncertainty

We recognize that, as a proxy for uncertainty, our cash flow volatility measures may not be perfect. In this section, we offer an alternative proxy for increased uncertainty and continue to find that this encourages the start of merger waves and predicts the preponderance of vertical integration within merger activity.

Our alternative proxy for increased uncertainty is the number of firms that had an increase (by 5% or greater) in the standard deviation of analysts' forecasts from $t-2$ to $t-1$ (where t is the year of the merger).[13] The control variables are the usual. Our results are presented in Table 6. The first three columns (Panel A) explain the start of merger waves. The last three (Panel B) explain the preponderance of vertical integration in merger activity on an industry/year basis (again using a Tobit). Within each panel, the first specification does not control for the number of firms in an industry. The second controls for it by removing industries in the highest decile of number of firms in an industry. The third includes a control variable for the number of firms in the industry.

[13] Forecast volatility comes from Institutional Brokers' Estimate System (IBES). It is the standard deviation of analysts' forecasts of annual earnings, scaled by stock price from the end of the prior month.

Table 6
Merger waves and vertical integration following uncertainty: dispersion proxy.

In Panel A, logit models with industry random effects are used to predict industry merger waves and the dependent variable equals unity if an industry starts a merger wave during that year. In Panel B, Tobit models with industry random effects are used to estimate whether the level of uncertainty affects the amount of vertical integration activity in an industry-year and the dependent variable is the percentage of mergers and acquisitions in an industry-year that are vertical integrations. The sample is 48 industries observed annually from 1981 through 2006. The explanatory variables are measured at the end of year $t-1$. *Increased uncertainty* is the number of firms, transformed by the natural log, experiencing a 5% or greater increase in the dispersion of analyst forecasts from $t-2$ to $t-1$. *B/M* is the industry median book-to-market ratio. The *3 Yr return* and σ(*3 Yr return*) are the industry-year median buy-and-hold return and the standard deviation of that return. *Spread* is the difference between the Baa rate and the Fed Funds rate. *Dereg indicator* is an indicator variable for deregulation periods, identified by Viscusi et al. (2005). *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. Numbers below each coefficient are *p*-values.

	Dependent variable					
	Panel A: Merger wave start indicator			Panel B: *VI/M_A*		
Increased uncertainty$_{t-1}$	0.632	0.670	0.539	0.131	0.164	0.126
	(0.000)	(0.002)	(0.022)	(0.000)	(0.000)	(0.000)
Industry size$_{t-1}$			0.001			0.000
			(0.574)			(0.778)
B/M$_{t-1}$	−0.372	−0.302	−0.340	−0.008	−0.008	−0.008
	(0.493)	(0.584)	(0.531)	(0.110)	(0.143)	(0.108)
3 Yr return$_{t-1}$	−1.206	−1.185	−1.233	−0.033	−0.056	−0.033
	(0.004)	(0.009)	(0.003)	(0.414)	(0.238)	(0.412)
σ(*3 Yr return*)$_{t-1}$	0.125	0.175	0.123	0.016	0.027	0.015
	(0.228)	(0.108)	(0.234)	(0.392)	(0.253)	(0.403)
Spread$_{t-1}$	−0.256	−0.244	−0.256	0.009	0.017	0.009
	(0.030)	(0.066)	(0.030)	(0.495)	(0.259)	(0.488)
Dereg indicator$_{t-1}$	1.134	1.196	1.065	0.019	−0.092	0.016
	(0.159)	(0.281)	(0.193)	(0.900)	(0.676)	(0.917)
Econ shock factor$_{t-1}$	0.210	0.184	0.212	−0.039	−0.027	−0.039
	(0.219)	(0.325)	(0.214)	(0.203)	(0.427)	(0.203)
Constant	−4.136	−4.334	−4.036	−0.139	−0.269	−0.138
	(0.000)	(0.000)	(0.000)	(0.101)	(0.007)	(0.104)
# Observations	1,186	1,056	1,186	1,186	1,056	1,186
# Industries	48	43	48	48	43	48
Exclude largest industries	No	Yes	No	No	Yes	No

All of the Table 6 results confirm our earlier findings that employed the original definition of increasing uncertainty. The coefficients on *Increased uncertainty* (measured by increased analyst forecast dispersion) are consistently positive and statistically significant—indicating that our alternative uncertainty proxy is positively related to both the likelihood of a merger wave start and the preponderance of vertical integration within industry merger activity. The additional Panel A coefficients mimic the Table 4 results. Both three-year returns and spreads demonstrate a negative relationship with the start of merger waves. Likewise, Panel B of Table 6 is similar to the Table 5 results, with *Increased uncertainty* carrying the only statistically significant coefficient for predicting the preponderance of vertical integration.

Computing the marginal (economic) effects for the full specifications in Panels A and B (columns 3 and 6), we find that a one-standard-deviation change in the uncertainty variable increases the likelihood of a wave start by 1.17% and the percentage of vertically related mergers by 7.85%. In Panel A, the likelihood of a wave start decreases by 1.11% with a one-standard-deviation change in three-year returns and by 0.66% for the same change in the spread. In Panel B, none of the other variables have similar magnitude marginal effects. Both sets of results are consistent with our risk management hypothesis.

4. Evidence from firm-level responses to uncertainty and vertical integrations

4.1. Individual firms' merger decisions

We deepen our analysis of the relation between cash flow uncertainty and merger activity by examining individual firm decisions to engage in vertically integrated mergers. Clearly, this type of analysis carries a selection concern as vertical integrations are observed only for firms which first decide to pursue a merger. To address this issue, we employ a Heckman model to control for the decision to engage in a merger in the first stage, and then explain the vertical integration decision in the second stage.

Table 7 presents results from the second stage of the process. In the first stage (untabulated results), we investigate determinants of merger decisions. The dependent variable in the logit is one if the firm engaged in a merger in that year, zero otherwise. Traditional variables are associated with increased likelihood of engaging in a merger: larger firms, more profitable ones with higher asset turnover, and lower leverage.

In the second stage, cash flow uncertainty continues to positively influence vertical integration decisions. However, the results are slightly weaker than in the case of industry and wave level vertical integration activity.

Table 7

Firm-level uncertainty and the decision to vertically integrate.

The decision to vertically integrate is estimated using a Heckman model to control for the decision to engage in M&A activity. The sample is firm-level data observed annually from 1981 through 2006. The second stage predicts the decision to vertically integrate. The explanatory variables are measured at the end of year $t-1$. *Vertical integration indicator* equals one if *Vertical coefficient factor*, calculated from the BEA I/O Tables, is greater than 1% (following Fan and Goyal, 2006). *Increased uncertainty* is the number of firms, transformed by the natural log, experiencing increased firm-level uncertainty for an industry-year. Uncertainty is measured as increases in either *COGS/TA* volatility or *OIBD/TA* volatility, where volatility is measured using 20 prior quarters of data and an increase is defined as increases in volatility for at least three of the prior four quarters (*Rolling increase*), or a 5% or 10% increase in volatility from the prior year-end quarterly measure. *Shock, 5% increase* (*decrease*) is the number of firms in an industry-year experiencing a 5% increase (decrease) to either OIBD (Panel A) or COGS (Panel B). The first-stage (unreported) decision to acquire is modeled as a function of firm control variables, the economic and behavioral factors of Harford (2005), and both year and industry dummy variables. *LnTA* is the natural log transformation of total assets. *COGS/TA* is the cost of goods sold scaled by total assets. *OIBD/TA* is the operating income before depreciation scaled by total assets. *Leverage* is long-term debt plus current portion of long-term debt, all scaled by total assets. *Sales/TA* is revenues scaled by total assets. *B/M* is the industry median book-to-market ratio. The *3 Yr return* and *σ*(*3 Yr return*) are the industry-year median buy-and-hold return and the standard deviation of that return. *Spread* is the difference between the Baa rate and the Fed Funds rate. *Dereg indicator* is an indicator variable for deregulation periods, identified by Viscusi et al. (2005). *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. Robust *p*-values are in parentheses.

Second stage	Dependent variable: vertical integration											
Uncertainty measure	Panel A: OIBD volatility						Panel B: COGS volatility					
	Rolling increase		5% Increase		10% Increase		Rolling increase		5% Increase		10% Increase	
Increased uncertainty$_{t-1}$	0.031	0.030	0.023	0.024	0.040	0.043	0.011	0.009	0.032	0.029	0.052	0.049
	(0.083)	(0.094)	(0.225)	(0.207)	(0.052)	(0.042)	(0.456)	(0.542)	(0.038)	(0.057)	(0.002)	(0.003)
Shock, 5% increase$_{t-1}$		0.047		0.056		0.055		0.030		0.031		0.027
		(0.031)		(0.011)		(0.012)		(0.151)		(0.151)		(0.215)
Shock, 5% decrease$_{t-1}$		−0.020		−0.010		−0.012		0.024		0.024		0.020
		(0.367)		(0.672)		(0.596)		(0.223)		(0.235)		(0.318)
Econ shock factor$_{t-1}$	−0.131	−0.131	−0.129	−0.129	−0.129	−0.129	−0.133	−0.132	−0.130	−0.129	−0.130	−0.129
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
B/M$_{t-1}$	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008	−0.008
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
3 Yr return$_{t-1}$	0.017	0.021	0.014	0.018	0.014	0.018	0.015	0.015	0.012	0.012	0.013	0.013
	(0.378)	(0.268)	(0.477)	(0.345)	(0.475)	(0.341)	(0.376)	(0.354)	(0.467)	(0.458)	(0.451)	(0.445)
σ(*3 Yr return*)$_{t-1}$	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.003	−0.003	−0.004	−0.004	−0.004	−0.004
	(0.231)	(0.237)	(0.256)	(0.274)	(0.263)	(0.281)	(0.441)	(0.430)	(0.392)	(0.394)	(0.298)	(0.308)
LnTA$_{t-1}$	0.002	0.005	0.002	0.005	0.002	0.005	0.008	0.009	0.008	0.008	0.008	0.008
	(0.855)	(0.697)	(0.895)	(0.718)	(0.905)	(0.729)	(0.430)	(0.406)	(0.469)	(0.452)	(0.477)	(0.463)
COGS/TA$_{t-1}$	−0.140	−0.140	−0.142	−0.143	−0.142	−0.143	−0.131	−0.130	−0.131	−0.130	−0.131	−0.130
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
OIBD/TA$_{t-1}$	−0.297	−0.327	−0.278	−0.303	−0.275	−0.302	−0.220	−0.212	−0.212	−0.203	−0.207	−0.200
	(0.001)	(0.000)	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.004)	(0.006)	(0.004)	(0.006)
Constant	0.833	0.773	0.857	0.783	0.855	0.782	0.685	0.660	0.688	0.666	0.687	0.668
	(0.003)	(0.005)	(0.003)	(0.006)	(0.003)	(0.006)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Observations	167,997	167,997	167,875	167,875	167,875	167,875	168,997	168,841	168,841	168,841	168,841	168,841

When cash flow uncertainty is measured using OIBD as the cash flow proxy, only the rolling shock variable and the 10% shock variable carry significantly positive coefficients. When COGS volatility proxies for cash flow uncertainty, the rolling shock measure is not a significant determinant of vertical integration. As we show below, we can partially attribute this to aggregating all firms. When we split our sample based on asset specificity, reflecting cross-sectional variation in the benefits of vertical integration, we obtain larger coefficients on the group where vertical integration is likely to be most beneficial as a risk management technique.

4.2. Asset specificity and vertical integration as risk management

Theory suggests that vertical integration is a response to increased uncertainty. However, the benefits are thought to be increasing in the specificity of the buyer's assets (Klein, Crawford, and Alchian, 1978; Williamson, 1979). Thus, among firms experiencing shocks to cash flow uncertainty, we expect vertical integration decisions to depend on asset specificity, with higher asset specificity firms being more likely to engage in vertical integration. To account for this, we re-run our Table 7 regressions, but with two dummy variables for increased cash flow uncertainty. The first dummy equals one when there is a shock to cash flow uncertainty *and* when the industry's asset specificity measure is above the annual cross-industry median. The other dummy equals one when there is a shock to cash flow uncertainty and the firm's industry asset specificity is below the annual median. Following Denis, Denis, and Sarin (1997), we proxy asset specificity with R&D/Sales.

Table 8 confirms that vertical integration's perceived benefits vary as theory would predict. For high asset specificity firms, the increased uncertainty coefficient is

Table 8
Asset specificity, firm-level integration, and the decision to vertically integrate.

The decision to vertically integrate is estimated using a Heckman model to control for the decision to engage in M&A activity. The sample is firm-level data observed annually from 1981 through 2006. The second stage predicts the decision to vertically integrate. The explanatory variables are measured at the end of year $t-1$. *Vertical integration indicator* equals one if *Vertical coefficient factor,* calculated from the BEA I/O Tables, is greater than 1% (following Fan and Goyal, 2006). *Industry adjusted R&D* is the deviation of the firm's R&D from the industry median. *Increased uncertainty* is the number of firms, transformed by the natural log, experiencing increased firm-level uncertainty for an industry-year. Uncertainty is measured as increases in either *COGS/TA* volatility or *OIBD/TA* volatility, where volatility is measured using 20 prior quarters of data and an increase is defined as increases in volatility for at least three of the prior four quarters (*Rolling increase)*, or a 5% or 10% increase in volatility from the prior year-end quarterly measure. Firms with *Increased uncertainty* are separated into industries with higher or lower asset specificity (defined as an industry R&D/Sales above or below the annual median). *Shock, 5% increase* (*decrease*) is the number of firms in an industry-year experiencing a 5% increase (decrease) to either OIBD (Panel A) or COGS (Panel B). The first-stage (unreported) decision to acquire is modeled as a function of firm control variables, the economic and behavioral factors of Harford (2005), and both year and industry dummy variables. *LnTA* is the natural log transformation of total assets. *COGS/TA* is the cost of goods sold scaled by total assets. *OIBD/TA* is the operating income before depreciation scaled by total assets. *Leverage* is long-term debt plus current portion of long-term debt, all scaled by total assets. *Sales/TA* is revenues scaled by total assets. *B/M* is the industry median book-to-market ratio. The *3 Yr return* and σ(*3 Yr return*) are the industry-year median buy-and-hold return and the standard deviation of that return. *Spread* is the difference between the Baa rate and the Fed Funds rate. *Dereg indicator* is an indicator variable for deregulation periods, identified by Viscusi et al. (2005). *Economic shock index* is the Harford (2005) first principal component of seven economic shock variables. Robust *p*-values are in parentheses.

Second stage	Dependent variable: vertical integration											
Uncertainty measure	Panel A: OIBD volatility						Panel B: COGS volatility					
	Rolling increase		5% Increase		10% Increase		Rolling increase		5% Increase		10% Increase	
Higher specificity & uncertainty$_{t-1}$	0.069	0.064	0.065	0.059	0.086	0.080	0.021	0.018	0.050	0.048	0.054	0.050
	(0.033)	(0.047)	(0.068)	(0.102)	(0.030)	(0.046)	(0.405)	(0.472)	(0.054)	(0.071)	(0.072)	(0.096)
Lower specificity & uncertainty$_{t-1}$	−0.059	−0.062	−0.028	−0.031	−0.052	−0.058	−0.131	−0.132	−0.083	−0.085	−0.050	−0.051
	(0.251)	(0.236)	(0.619)	(0.585)	(0.405)	(0.353)	(0.001)	(0.001)	(0.063)	(0.059)	(0.318)	(0.306)
Shock, 5% increase$_{t-1}$		0.051		0.066		0.068		0.024		0.021		0.020
		(0.140)		(0.060)		(0.054)		(0.414)		(0.481)		(0.514)
Shock, 5% decrease$_{t-1}$		0.050		0.054		0.054		0.036		0.035		0.034
		(0.171)		(0.145)		(0.146)		(0.186)		(0.207)		(0.225)
LnTA$_{t-1}$	−0.022	−0.020	−0.022	−0.019	−0.021	−0.019	−0.032	−0.031	−0.033	−0.033	−0.035	−0.034
	(0.141)	(0.179)	(0.167)	(0.225)	(0.170)	(0.229)	(0.004)	(0.005)	(0.004)	(0.005)	(0.003)	(0.003)
COGS/TA$_{t-1}$	−0.134	−0.132	−0.139	−0.137	−0.137	−0.135	−0.098	−0.095	−0.103	−0.100	−0.107	−0.104
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
OIBD/TA$_{t-1}$	−0.122	−0.099	−0.086	−0.066	−0.086	−0.066	−0.124	−0.117	−0.116	−0.111	−0.113	−0.108
	(0.258)	(0.382)	(0.461)	(0.590)	(0.459)	(0.589)	(0.107)	(0.130)	(0.154)	(0.175)	(0.177)	(0.197)
Econ shock factor$_{t-1}$	−0.115	−0.114	−0.119	−0.118	−0.120	−0.119	−0.128	−0.127	−0.129	−0.129	−0.130	−0.130
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
B/M$_{t-1}$	−0.005	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
3 Yr return$_{t-1}$	−0.053	−0.051	−0.056	−0.053	−0.055	−0.052	−0.027	−0.026	−0.031	−0.030	−0.032	−0.031
	(0.084)	(0.098)	(0.069)	(0.084)	(0.075)	(0.090)	(0.286)	(0.309)	(0.240)	(0.259)	(0.228)	(0.245)
σ(*3 Yr return*)$_{t-1}$	−0.006	−0.005	−0.009	−0.009	−0.009	−0.008	0.001	0.000	−0.001	−0.002	−0.002	−0.002
	(0.669)	(0.678)	(0.487)	(0.499)	(0.497)	(0.514)	(0.956)	(0.981)	(0.907)	(0.888)	(0.875)	(0.855)
Constant	1.104	1.043	1.112	1.032	1.107	1.027	1.250	1.219	1.272	1.244	1.301	1.274
	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Observations	79,879	79,879	79,821	79,821	79,821	79,821	80,481	80,481	80,400	80,400	80,400	80,400

generally significantly positive. Notably, the coefficients on uncertainty among the high asset specificity firms in Table 8 are typically about 100% larger than the coefficients on uncertainty in Table 7. By contrast, the coefficient on cash flow uncertainty among low asset specificity firms is always negative, though significant only sporadically. The difference in the two groups' relations between cash flow uncertainty and vertical integration is statistically significant.

Our results support the theory that vertical integration is a risk management device in the face of increased cash flow uncertainty, particularly where the benefits are thought to be greatest (i.e., when asset specificity is high). Taken together with the above results, cash flow uncertainty is a critical determinant of vertical integration activity at the firm-level and the industry-level, and it encourages the start of merger waves.

4.3. *The risk management benefits of vertical integration*

To buttress our claims that vertical integration helps firms manage risk, we investigate post-acquisition characteristics. We first study the influence of vertical integration on a firm's change in costs of goods sold. This directly measures the value of vertical integration as a hedge in terms of the bottom line effects on cash flow. We then study the effects of vertical integration on firms' use of slack. These tests recognize that slack is costly but tends to be carried as a hedge against uncertainty (Kim, Mauer, and Sherman, 1998, among others). If vertical

Table 9
Post merger changes.

Firm-level fixed effect regressions are used with instrumental variables to estimate the impact of vertical integration. The sample is firm-level data observed annually from 1981 through 2006. In Panel A, the dependent variable is the change in COGS and slack over two- and four-year event windows. Δ*LnTA* is the change in the natural log transformation of total assets. *Leverage* is long-term debt plus current portion of long-term debt, all scaled by total assets. *COGS/TA* is the cost of goods sold scaled by total assets. *Slack/TA* is cash and marketable securities scaled by total assets. In Panel B, the dependent variable is the percent change in either OIBD or COGS volatility. The "before" volatility is calculated over the 20 quarters preceding the event and the "after" period is calculated as either the 20 quarters immediately following the event (years 1–5) or the 20 quarters after excluding two post-event years (years 3–7). *OIBD/TA* is operating income before depreciation scaled by total assets. In both panels, the instruments for the decision to vertically integrate are lags of *LnTA*, *Spread*, and the annual industry median *COGS/TA* volatility. Robust *p*-values are in parentheses.

Panel A: Changes in COGS and slack

	Δ*COGS/TA*				Δ*Slack/TA*			
	$t+1, t-1$		$t+3, t-1$		$t+1, t-1$		$t+3, t-1$	
Vertical integration	−50.820	−2.442	−35.840	−2.187	−1.131	−0.287	−0.763	−0.084
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.054)
$\Delta LnTA_{t+1,\ t-1\ (t+3,\ t-1)}$	−1.013	−0.166	−0.901	−0.100	0.005	−0.010	−0.006	−0.011
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.018)	(0.000)	(0.000)
$Leverage_{t-1}$	0.004	0.155	0.004	0.225	0.000	0.011	0.000	−0.054
	(0.602)	(0.116)	(0.699)	(0.019)	(0.206)	(0.406)	(0.067)	(0.000)
$COGS/TA_{t-1}$	−1.111	−0.752	−1.028	−0.844	0.000	0.009	0.001	0.008
	(0.000)	(0.000)	(0.000)	(0.000)	(0.778)	(0.068)	(0.020)	(0.052)
$Slack/TA_{t-1}$	−0.694	0.282	0.151	0.253	−0.787	−0.825	−0.939	−0.934
	(0.292)	(0.104)	(0.844)	(0.169)	(0.000)	(0.000)	(0.000)	(0.000)
# Observations	167,306	7,534	122,116	5,778	160,624	7,536	122,318	5,780
# Firms	19,211	3,299	15,197	2,627	19,213	3,303	15,207	2,628
Limited to M&A	No	Yes	No	Yes	No	Yes	No	Yes

Panel B: Changes in volatility

	Δ*OIBD* volatility		Δ*COGS* volatility	
	$t+5, t-1$	$t+7, t-1$	$t+5, t-1$	$t+7, t-1$
Vertical integration	−4.793	−33.770	4.313	−13.790
	(0.010)	(0.000)	(0.694)	(0.095)
$LnTA_{t-1}$	0.254	0.987	−0.277	0.644
	(0.000)	(0.000)	(0.418)	(0.014)
OIBD volatility$_{t-1}$	−0.849	−0.822		
	(0.000)	(0.114)		
$OIBD/TA_{t-1}$	0.168	0.502		
	(0.000)	(0.013)		
COGS volatility$_{t-1}$			−3.547	−2.948
			(0.001)	(0.000)
$COGS/TA_{t-1}$			−0.604	−0.594
			(0.042)	(0.007)
# Observations	24,363	19,067	36,369	28,701
# Firms	3,765	3,013	4,984	4,008

integration helps hedge against uncertainty, the need to carry costly slack is diminished.[14] Lastly, we measure the influence of vertical integration on firms' cash flow volatilities. Again, if vertical integration helps hedge uncertainty, we should observe declines in cash flow uncertainty related to vertical integration.

4.3.1. Cost and slack reductions

The results on changes in costs and slack are presented in Panel A of Table 9. We measure the changes over the following two yearly windows: [−1,+1] and [−1,+3]. We regress changes in *COGS/TA* or *slack/TA* on vertical integration and controls for asset changes, leverage, lagged *COGS/TA*, and lagged slack-to-assets. These tests are complicated by the endogenous relationship between vertical integration and either COGS or slack. Since this endogeneity cannot be addressed with a simple difference-in-differences estimation, we employ an instrumental variable approach. We instrument for vertical integration with lagged versions of size, spread, and median annual industry *COGS/TA* volatility.[15]

We run two specifications for each time window. The first is for the full sample, the second is for the subsample of M&As. Across the board, vertical integration associates

[14] We are not suggesting that firms will engage in merger only to reduce their need to carry costly slack. The former may indeed be more expensive than the latter. However, given other incentives to merge (i.e., risk management), these firms may take advantage of their new ability to reduce slack with less concern that they will face costly external financing later.

[15] However, our results are robust to alternative instrumental variable choices.

with lower COGS and less slack used. Despite smaller (in absolute value) coefficients in the regressions on the subsample of M&A firms, the results are still significant. Even among firms choosing to merge, vertical integration leads to larger reductions in COGS and slack than other combinations.

4.3.2. Changes in cash flow volatility

The results on change in uncertainty are presented in Panel B. We measure changes in volatility between a "before" period and an "after" period. The "before" window is the 20 quarters preceding the event. As with the previous subsection, we consider two alternatives "after" time windows: the 20 quarters immediately following the event (years 1–5), or the 20 quarters after excluding the first two post-event years (years 3–7). We regress percent changes in cash flow volatility on vertical integration and controls for assets, prior cash flow levels, and prior cash flow volatilities. Again, we instrument the vertical integration variable with lagged size, spread, and median annual industry *COGS/TA* volatility.

With one exception (change in COGS-based volatility, over the shorter window), we find vertical integration associates with a reduction in cash flow volatility. The lone exception actually may be due to an outlier, as we re-estimate (in unreported results) the regression with variables winsorized at the 1% and 99% levels. In that case, vertical integration associates with reductions in cash flow uncertainty across all specifications.

5. Conclusion

We study the role of risk management in merger activity and specifically focus on how the decision to vertically integrate contributes to merger waves. In our cross-sectional and panel analyses, we examine merger waves, aggregate industry merger patterns, and firm-specific merger decisions. There is substantial evidence that risk management plays an important role in merger activity at the firm and industry levels and contributes to the start of merger waves.

We begin by highlighting the clustering of vertical integration within merger waves and show that the level of vertical integration activity within an industry is positively associated with merger waves. Since the industrial organization literature contends that vertical integration is an effective risk management tool, we explore whether risk management considerations are relevant to understanding merger waves.

Our research directly links cash flow volatility increases with the start of merger waves. This is consistent with the joint hypothesis that firms may want to hedge cash flow uncertainty (Froot, Scharfstein, and Stein, 1993), and that mergers may be used as an operational hedge (Hirshleifer, 1988; Penas and Unal, 2004). Thus, merger waves appear to be partly driven by a desire to hedge cash flow uncertainty. We support this conclusion by studying the vertical integration decision at the aggregate industry level and firm level. The percentage of an industry-year's mergers that are vertical is strongly related to cash flow uncertainty, even in non-wave periods. This suggests that risk management considerations do not depend on unique characteristics that also may correlate with merger waves. Further, we show that individual firm vertical integration decisions are influenced by cash flow uncertainty. This is particularly the case when a firm's asset specificity is high, consistent with the theoretical benefits of vertical integration as a hedge against uncertain cash flows.

Given the apparent attempt to manage risk via vertical integration, we inquire as to the effectiveness of this mechanism. Vertically integrating firms experience significant reductions in costs and they reduce their use of slack (an alternative risk management tool). We also find that these firms experience a reduction in cash flow volatility as a result of the vertical merger. These results are consistent with vertical integrations providing operational hedging benefits. A more detailed analysis of hedging with financial instruments versus hedging via merger is a potentially fruitful area of future research.

References

Ahern, K.R., Harford, J., 2009. The importance of industry links in merger waves. Unpublished Working Paper, University of Michigan and University of Washington.

Amihud, Y., Lev, B., 1981. Risk reduction as a managerial motive for conglomerate mergers. Bell Journal of Economics 12, 605–617.

Billett, M.T., Garfinkel, J.A., 2004. Financial flexibility and the cost of external finance for U.S. bank holding companies. Journal of Money, Credit and Banking 26, 827–852.

Bouwman, C.H.S., Fuller, K., Nain, A.S., 2009. Market valuation and acquisition quality: empirical evidence. Review of Financial Studies 22, 633–679.

Cai, J., Vijh, A., 2007. Incentive effects of illiquid stock and option holdings of target and acquirer CEOs. Journal of Finance 62, 1891–1933.

Carlton, D.W., 1979. Vertical integration in competitive markets under uncertainty. Journal of Industrial Economics 27, 189–209.

Denis, D.J., Denis, D.K., Sarin, A., 1997. Agency problems, equity ownership, and corporate diversification. Journal of Finance 52, 135–160.

Fama, E.F., French, K.R., 1997. Industry costs of equity. Journal of Financial Economics 43, 153–193.

Fan, J.P.H., 2000. Price uncertainty and vertical integration: an examination of petrochemical firms. Journal of Corporate Finance 6, 345–376.

Fan, J.P.H., Goyal, V.K., 2006. On the patterns and wealth effects of vertical mergers. Journal of Business 79, 877–902.

Fee, C.E., Thomas, S., 2004. Sources of gain in horizontal mergers: evidence from customer, supplier, and rival firms. Journal of Financial Economics 74, 423–460.

Froot, K., Scharfstein, D., Stein, J., 1993. Risk management: coordinating corporate investment and financing policies. Journal of Finance 48, 1629–1658.

Goel, A.M., Thakor, A.V., 2010. Do envious CEOs cause merger waves? Review of Financial Studies 23, 487–517

Greene, W., 2004. Fixed effects and bias due to the incidental parameters problem in the Tobit model. Econometric Reviews 23, 125–147.

Hankins, K.W., 2009. How do financial firms manage risk? Unraveling the interaction of financial and operational hedging. Management Science, forthcoming, doi:10.1287/mnsc.1090.1068.

Harford, J., 2005. What drives merger waves? Journal of Financial Economics 77, 529–560

Hertzel, M., Li, A., Officer, M., Rodgers, K., 2008. Inter-firm linkages and the wealth effects of financial distress along the supply chain. Journal of Financial Economics 87, 374–387.

Hirshleifer, D., 1988. Risk, future pricing, and organization of production in commodity markets. Journal of Political Economy 96, 1206–1220.

Johnson, S., Houston, M., 2000. A reexamination of the motives and gains in joint ventures. Journal of Financial and Quantitative Analysis 35, 67–85.

Kedia, S., Ravid, S.A., Pons, V., 2008. Vertical mergers and the market valuation of the benefits of vertical integration. Unpublished Working Paper. Rutgers University, University of Pennsylvania, and Renaissance Capital, London.

Kim, C., Mauer, D., Sherman, A., 1998. The determinants of corporate liquidity: theory and evidence. Journal of Financial and Quantitative Analysis 33, 335–359.
Klein, B., Crawford, R.G., Alchian, A.A., 1978. Vertical integration, appropriable rents, and the competitive contracting process. Journal of Law and Economics 21, 297–326.
Lambrecht, B.M., 2004. The timing and terms of mergers motivated by economies of scale. Journal of Financial Economics 72, 41–62.
Matsusaka, J.G., 1996. Did tough antitrust enforcement cause the diversification of American corporations? Journal of Financial and Quantitative Analysis 31, 283–294
Mitchell, M.L., Mulherin, J.H., 1996. The impact of industry shocks on takeover and restructuring activity. Journal of Financial Economics 41, 192–229.
Opler, T., Pinkowitz, L., Stulz, R., Williamson, R., 1999. The determinants and implications of corporate cash holdings. Journal of Financial Economics 52, 3–46.
Ovtchinnikov, A.V., 2010. Capital structure decisions: evidence from deregulated industries. Journal of Financial Economics 95, 249–274.
Penas, M.F., Unal, H., 2004. Gains in bank mergers: evidence from the bond markets. Journal of Financial Economics 74, 149–179.
Rhodes-Kropf, M., Robinson, D.T., Viswanathan, S., 2005. Valuation waves and merger activity: the empirical evidence. Journal of Financial Economics 77, 561–603.
Shleifer, A., Vishny, R.W., 2003. Stock market driven acquisitions. Journal of Financial Economics 70, 295–311.
Viscusi, W.K., Harrington Jr., J.E., Vernon, J., 2005. Economics of Regulation and Antitrust, fourth ed. MIT Press, Cambridge, MA.
Wall Street Journal, 2006. A Hot Commodities Market Spurs Buying Spree by Manufacturers, August 14.
Wall Street Journal, 2009. Companies More Prone to go 'Vertical', December 1.
Williamson, O.E., 1971. The vertical integration of production: market failure considerations. American Economic Review 61, 112–123.
Williamson, O.E., 1979. Transaction-cost economics: the governance of contractual relations. Journal of Law and Economics 22, 233–261.