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Corporate risk management: evidence from product liability

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1. Introduction

In this paper we examine the factors that determine how firms manage large, firm-specific risks, in this case, product liability. The risk of being sued for defective products or damage from defective products poses a small probability of a great loss to the firm. Product liability exposure arises from the firm's choice of products and markets; choices that are fundamental to the firm's business strategy and that are costly to alter. Firms are unlikely to be naturally hedged by cash flows with respect to product liability risk. Cash flows will likely be negatively correlated with product liability claims since product liability claims reduce product demand and increase costs through legal expenses and claims payments.

We study the impact of this low-probability, high-loss risk on a group of firms that manage product liability through insurance purchases in the early 1980s. Thus in the early 1980s all our firms follow similar strategies for managing product liability exposure. In 1985 a sudden, substantial rise in the price of product liability insurance causes firms to re-evaluate their risk management choices. We study the relationship between firms' subsequent product liability risk management choices and firm characteristics that affect risk management choices. In particular, we examine firm characteristics related to risk capacity, costs of financial distress, and managerial incentives on the decision to continue purchasing product liability insurance.

The decision to purchase product liability insurance depends upon the optimal risk management strategy for the firms as well as private managerial incentives that might cause

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managers to choose more or less insurance than the value-maximizing strategy. We define the optimal risk management strategy as the one that maximizes expected firm value taking into account three possible events: no product liability loss, loss without financial distress, and loss with financial distress. Firms are less likely to purchase insurance if they have smaller probability and size of loss, greater risk capacity, and lower costs of financial distress. Risk management decisions may further be influenced by agency costs due to managerial preferences for risk management. For example, the form of managerial compensation may alter managers' risk preferences. While managerial compensation is generally intended to align the incentives of the firm and its managers, it may not accomplish this at all times. Thus, in our analysis of risk management choices we control for private incentives provided by managers' compensation schemes. We group our explanatory variables into four groups: risk probability and size, risk capacity, costs of financial distress, and managerial compensation incentives.

Our results show that the last three factors play an influential role in firms' decisions whether to continue purchasing insurance after the price increase. Firms with higher risk capacity as measured by larger firm size, lower expected cost of external financing, and no debt financing are significantly less likely to continue purchasing insurance. Further, firms with low costs of financial distress—as indicated by very high leverage or the absence of net operating loss carryforwards (NOLs)—are less likely to purchase insurance. Finally, firms whose managers have more options are also less likely to continue purchasing insurance. When we decompose the total number of options into three categories: those clearly in-the-money, those clearly out-of-the-money, and options that we cannot classify from information in financial statements, we find that the most significant effect of options arises from out-of-the-money options.

We revisit our firms five years after the liability crisis to investigate whether firms that stop purchasing liability insurance exhibit greater firm risk than those that continue to hedge. With this longer horizon, we expect firms to re-optimize firm characteristics as well as risk management choices. We find that the non-purchasing group generally increased risk-bearing capacity and reduced overall firm risk more than the group that continued to buy insurance. The finding is strongest for measures of overall risk. Our finding is consistent with a model of risk management where, in the longer run, firms adjust multiple aspects of firm policy to optimize overall risk bearing relative to the change in the price of insuring product liability risk. That is, firms in the non-purchasing group decrease their overall firm risk as they increase their exposure to product liability risk.

Our study complements the existing literature on empirical corporate risk management by extending the analysis to large, firm-specific risks. Other studies have generally examined the use of derivatives where data is generally more available than data on insurance purchases. However, recent research suggests that the risks covered by derivative use may be short term and relatively small on average (see [Hentschel and Kothari, 2001](#)).¹ We argue that studying derivative use is also complicated by the availability of perfect substitutes for

¹ Hentschel and Kothari find that firms using derivatives do not exhibit lower or higher risk than those that do not. The authors note this is “consistent with [Stulz's \(1996\)](#) argument that firms primarily use derivatives to reduce the risk associated with short term contracts” and that the associated cash flows “represent a small fraction of firm value.”

derivatives use. For example, instead of using interest rate derivatives to offset risk from floating rate debt, a firm could issue fixed rate debt to accomplish the same outcome.² In contrast to these observations about derivatives, product liability risk represents a small probability of a large loss to the firm over a longer period of time. A study of the decision to insure product liability exposure is less likely to be impacted by a firm's other actions because there are no close substitutes for product liability insurance as a means to finance product liability claims. Although changes in formulations and packaging may reduce the product liability exposure these activities cannot remove the risk, leaving value to the firm from using insurance to finance product liability risk.

The paper is organized as follows. We begin with an overview of product liability insurance and the liability insurance crisis in Section 2. In Section 3, we present a stylized model of a firm's risk management decision and discuss managerial incentives for asymmetric hedges like insurance. We describe our data in Section 4 and provide estimation results in Section 5. In Section 6, we discuss our findings, compare them with those of existing studies, and suggest avenues for future research.

2. Product liability risk and the liability crisis

Product liability exposure is related to defective products or damage from defective products. The potential costs, conditional on a claim, are substantial. For example, the costs of product liability exposure to the general aviation industry increased from \$24 million to \$210 million while fatal accidents fell 21% between 1977 to 1985 (Mahoney and Littlejohn, 1989; Carlson, 1989). In the pharmaceutical industry, the annual number of lawsuits filed and the number of different defendants doubled between 1981 and 1986, excluding the two biggest litigation products (Mahoney and Littlejohn, 1989). Liability claims hurt the company directly through judgments or settlements and legal fees and indirectly through loss of firm or product reputation. The combined effect of the direct and indirect costs may contribute to higher costs of external funds at a time when the firm needs additional funds to deal with the liability challenges. Product liability may further reduce the firm's expected value by raising the probability that positive NPV investments will not be made if liability claims arise.

Given the significance of product liability exposures, many firms seek to manage this exposure. Risk control activities include carefully assessing production methods, instituting quality control measures and altering consumer packaging and information. However, since product liability exposure cannot be eliminated this way, many firms transfer product liability exposure with insurance.³ Insurers typically price product liability policies on a risk-by-risk basis as opposed to one price that applies to all firms with the same product.

² A recent study on the use of interest rate derivatives by Faulkender (2003) is the first we know of that deals with this question by focusing on the total interest rate exposure of the firm, rather than just the use of derivatives. Faulkender's results are more consistent with speculation or myopia driving the use of derivatives rather than hedging.

³ In this period, product liability coverage was typically included in a firm's general liability contract. Some exclusions for product liability might apply; for example, most policies do not cover liability associated with a

The premium is a function of level of exposure, typically measured by the amount of revenue a product generates. Although firms' exposure to product liability and the cost and importance of product liability insurance increased in the years prior to the liability crisis, manufacturers were generally able to purchase product liability insurance.⁴

In late 1984 through 1986 the market for product liability insurance changed dramatically. In a matter of months, the insurance market became characterized by rapidly rising premiums for extremely limited coverage. Firms were often offered policies with lower aggregate limits and higher deductibles, at premiums several times higher than their previous policies. Weber (1987) reports that fewer than 39% of surveyed firms had expanded coverage limits below \$50 million prior to 1986, whereas more than 65% had limits below \$50 million in 1986.⁵ Forty-eight percent of surveyed firms paid more than \$500,000 for expanded coverage in 1986, compared to less than 10% from 1982–1985. At the same time, some insurers were enjoying rapidly increasing profitability. This event has become known as the liability crisis of 1985–1986.

The liability crisis represents a shift in the relative price of financing product liability exposure. Harrington (1988) and Harrington and Danzon (1994) show that only part of the increase in product liability premiums can be explained by increases in expected losses. Moreover, the increase in expected costs began in the late 1970s and continued into the 1980s while insurance premiums were relatively stable, even falling, until 1985. At that time, it appeared that prices increased faster than expected losses, resulting in an increase in insurers' margins. These observations support the capacity-constraint theory that hypothesizes that insurance market disruptions are related to temporary reductions in industry capacity.⁶ This theory argues that industry capital determines the capacity to bear risk and that it is costly to rapidly increase capital. Thus, after significant declines in industry capital, the remaining capital receives an abnormally high return, reflecting the temporary scarcity.

Our investigation examines manufacturers' response to this shift in the price of financing product liability exposure.⁷ Throughout, our interpretations rely on the liability crisis being an event that firms did not anticipate. Although some industry observers were sure the insurance market conditions would tighten, the timing and the severity of the event

product recall. The cost of defending a product liability suit is included in the insurance policy but prior to 1985 was not part of the aggregate policy limit. After 1985 defense costs were included in some aggregate policy limits.

⁴ Viscusi (1991) describes how changes in product liability increased the expense of product liability insurance.

⁵ The survey covered product and professional liability insurance from 1982–1986 for 232 US corporations with annual sales over \$100 million in "manufacturing, trade, and service." Expanded coverage refers to coverage over the standard business policy. Weber reports that price and availability problems were most severe in expanded coverage.

⁶ For more on the capacity constraint theory of insurance cycles see, among others, Winter (1988, 1991, 1994) and Gron (1994a, 1994b). Winter (1991) provides a good discussion of the liability crisis in general and alternative theories about the causes of the crisis.

⁷ We assume that cross-sectional differences in risk management result from buyers' choices. Alternatively, these differences might reflect adverse selection due to asymmetric information between insurance buyers and sellers. Severe adverse selection is one explanation of the liability crisis but recent research provides alternative hypotheses (Gron and Winton, 2001). If market failure due to adverse selection is a primary determinant of who continues to insure, the limited quantities of insurance would be unrelated to risk-bearing variables.

was unknown.⁸ Given the relatively low prices for liability insurance that prevailed until the crisis, firms had little incentive to undertake alternative risk management activities in anticipation of the market change.

3. Risk management overview

Firms undertake risk management to reduce adverse consequences of risk on firm value. In addition, managers may have private incentives to choose a different level of risk management. While we generally expect managers' and shareholder's interests to be aligned, the optimal risk management for the two groups may diverge due to incentives from managerial compensation.

Once a risk exposure is identified, the manager can control the risk, transfer the risk, do both or do neither. The choice of action depends upon relative costs, benefits and substitutability of these activities. Risk control reduces the probability or magnitude of loss. Risk transfer does not affect the probability or magnitude of a loss but transfers the financial effect of the loss to a third party who promises contingent financing. In this section, we present a model of value-maximizing, short-run risk control and risk transfer and discuss the implications for our product liability setting. We then discuss additional managerial incentives for risk management.

3.1. Value maximizing risk management incentives

Once the firm identifies a risk, the decision of how much risk control or risk financing to undertake follows the usual marginal benefit, marginal cost argument. The following stylized model illustrates the decision process. Let Π be profit in the absence of loss. Let the random variable L characterize the risky loss event; the realization of L lies within the interval $(0, \bar{L}]$ with probability of a loss p that a loss occurs. If the loss is severe, the firm experiences an additional cost of financial distress, C , with probability q . Thus without risk management the firm's expected value, $E[V]$, is equal to the no-loss profit less the expected loss given a loss event, less the expected costs of financial distress given a loss event or $E[V] = \Pi - pE[L] - pqC$.

The firm can reduce the impact of risk on expected value by investing in risk control, r_c , and investing in risk transfer, r_t . The probability of loss, the expected loss conditional on the loss event, and the probability of financial distress conditional on a loss event are all decreasing in r_c . The specific functional forms of $p(r_c)$, $E[L(r_c)]$ and $q(r_c)$ will vary with the type of risk and risk control technology.⁹ When a firm invests r_t in risk transfer,

⁸ Industry observers had been warning of a change in market conditions since the early 1980s, but none had come. Some insurers did raise prices in the early 1980s but subsequently lowered them after losing significant market share.

⁹ For example, when variable rate debt is replaced with fixed rate debt to control interest rate exposure the minimum of the probability and amount of loss functions could both be zero. In contrast, product redesign and new usage instructions and warnings used to control product liability exposure cannot completely eliminate the probability or magnitude of loss, thus the lower range of the probability and amount of loss functions will occur

it receives a payment of $I(r_t)$ conditional on the outcome of the uncertain event. Indemnity payments increase with risk transfer and the probability of financial distress decreases with risk transfer. Once again, the specific functional forms of $I(r_t)$ and $q(r_c, r_t)$ depend upon the risk and risk transfer.¹⁰

For both risk control and risk transfer, we assume there are small fixed costs to setting up programs and writing contracts. These costs are not required for the results but make the analysis attractive by providing a discontinuity.¹¹ The firm’s maximization problem now becomes:

$$\max_{r_c, r_t, \lambda, \gamma} \{ \Pi - r_c - r_t \} - p(r_c)[E[L(r_c)] - I(r_t)] - p(r_c)q(r_c, r_t)C - \lambda(r_c - v) - \lambda(r_t - \varepsilon),$$

where λ and γ are the multipliers on the constraints for risk control, r_c , and risk transfer, r_t , respectively. This is a short run model in that we fix characteristics that influence the probability of financial distress and the costs of financial distress such as leverage and working capital. There are four cases:

- (i) risk control and risk transfer ($r_c > v, r_t > \varepsilon$),
- (ii) risk control only ($r_c > v, r_t = 0$),
- (iii) risk transfer only ($r_c = 0, r_t > \varepsilon$), and
- (iv) no risk control and no risk transfer ($r_c = 0, r_t = 0$).

When the firm invests in both actions, the first order conditions (1) and (2) determine the optimal level of risk control and risk transfer:

$$1 = -\frac{\partial p(r_c)}{\partial r_c} [E[L(r_c)] - I(r_t) + q(r_c, r_t)C] - p(r_c) \left[\frac{\partial q(r_c, r_t)}{\partial r_c} C + \frac{\partial E[L(r_c)]}{\partial r_c} \right] - \lambda, \tag{1}$$

$$1 = \frac{\partial I(r_t)}{\partial r_t} p(r_c) - \frac{\partial q(r_c, r_t)}{\partial r_t} C - \gamma, \tag{2}$$

where the multipliers, λ and γ , are zero. As seen in Eq. (1), the marginal benefit of a risk control dollar is the net change in expected value due to a reduction in the probability of loss, a reduction in the probability of financial distress, and a reduction in the mean loss. Equation (2) shows that the marginal benefit from a dollar of risk transfer is the net

at a value greater than zero. Finally, the form of the probability of financial distress given a loss function also depends upon the type of risk and the specific risk control.

¹⁰ If a firm uses derivatives to hedge interest rate risk, the indemnity function will be perfectly correlated with the underlying risk and will include positive and negative payments. Alternatively, if a firm uses insurance to hedge product liability risk, the indemnity function will be less correlated with the loss due to policy deductibles, policy limits, and uncovered losses such as reduced future sales.

¹¹ Specifically, if v is a small, positive number then probability of loss, amount of loss, and probability of financial distress given a loss functions are strictly decreasing in r_c when $r_c > v$ and constant when $r_c \leq v$. Further, if ε is a small, positive number then when $r_t \leq \varepsilon$, the indemnity payment is zero and the indemnity payment and the probability of financial distress given a loss do not change with a change of risk transfer.

change in expected value due to the increased indemnification and the decreased probability of financial distress. The two decisions are substitutes: an increase in either decreases the benefit of the other. The net effect of a marginal change in either risk control or risk transfer will also depend on the sign and magnitude of the cross derivative of the probability of financial distress. Determining this sign requires more structure, but the cross derivative is unlikely to be large enough to offset these other effects and overturn the substitutability.

When either r_c or r_t is zero, the marginal benefits of the first dollars invested in risk transfer or risk control are less than the marginal costs. From Eq. (1), the marginal benefit of risk control is lower when the expected cost of the risk is lower and when the additional risk control dollar yields a smaller decrease in the expected cost of risk. The expected cost of risk increases in the probability of loss, the expected loss, and the expected costs of financial distress. The expected cost of risk decreases in the indemnity payment. The change in the expected cost of risk due to an additional risk control dollar depends on the decline in the probability of loss, the decline in the mean loss and the decline in the probability of financial distress. No risk transfer is more likely the lower the costs of financial distress, the probability of a loss, and the effectiveness of a dollar of risk transfer. The effectiveness of risk transfer has two components: as the firm invests more in risk transfer, the probability of financial distress declines and indemnity payment increases; risk transfer is more effective when the absolute magnitude of these changes are greater.

Our study focuses on this last case by investigating the differences among firms that stop buying product liability insurance and those that do not. In our sample all firms purchase product liability insurance in the early 1980s. The insurance industry then experienced a sudden and substantial increase in product liability premiums and decrease in available coverage. In our model, this corresponds to a decline in the indemnity function and its derivative at any level of risk transfer. Our model predicts that firms with higher costs of financial distress and with higher probability of loss are more likely to continue to purchase product liability insurance risk after the increase in price. In addition, firms whose probability of financial distress declines more with risk transfer and firms facing a lower marginal price for insurance are more likely to continue purchasing. Our model also predicts an increase in risk control although we do not observe data on risk control. While risk transfer and risk control are substitutes, product liability risk control is an imperfect substitute for product liability insurance.¹² We capture increased risk control opportunities that vary systematically among industries using industry effects. If there is no relationship between risk control and our explanatory variables, not accounting for risk control will tend to bias our estimation results toward zero.¹³

¹² New instructions or redesigned products will not remove product liability exposure; insurance does not cover all losses from product liability. If this is not the case *and* further risk control is correlated with our explanatory variables, our estimates capture the net effect these variables on risk transfer and the correlation with risk control.

¹³ We argue that tax incentives for risk management are not important for product liability risk. The convex tax schedule implies that lowering income variance reduces tax payments. Although product liability risk increases *expected* income variance significantly, the actual variance may not change since the probability of a large loss is low.

3.2. Managerial incentives for corporate risk management

Managerial incentives may also influence corporate risk management decisions. Managers who own firm stock are not well-diversified since their human and financial capital are tied to the firm's performance. In choosing the managerial compensation contract, a value-maximizing firm considers the costs and benefits of increasing risk-averse managers' exposure to variations in firm value. Risk management may be complementary to some forms of managerial compensation and so these decisions may be jointly determined. In our context, however, we relate changes in insurance purchase to managerial compensation just prior to the change in the insurance market. In the short run, managers will decide whether to continue with insurance or not but the firm cannot quickly change the incentives from managerial compensation since past stock and option grants still affect managerial decisions.

The effect of compensation on managers' risk management preferences depends upon the form of compensation and the risk exposure. It is well known that stock ownership and linear profit sharing tend to increase managerial preferences for risk management. [Smith and Stulz \(1985\)](#) and [Tufano \(1996\)](#) show that compensation that is convex in the expected firm value such as bonus plans or stock options may decrease managerial preferences for risk management. Both papers analyze risks that increase the expected variance of firm value and symmetric hedges whose costs are small relative to the expected firm value such as interest rate exposure and interest rate derivatives.

In contrast, product liability risk is an asymmetric exposure since "good" outcomes do not effect firm value while "bad" outcomes decrease firm value. Insurance contracts are similarly asymmetric—they limit downside risk but not upside outcomes. Risk-averse managers' incentives to use asymmetric hedges are complicated. In [Appendix A](#) we show that preferences for not purchasing insurance will be stronger for managers with options when there are increases in the expected loss, the probability of loss, or the mark-up on insurance. We argue that greater stock option compensation reduces managers' preferences for product liability insurance since these losses are large, infrequent events and the insurance has a positive mark-up.¹⁴

3.3. Measuring incentives to purchase product liability insurance

We organize firm characteristics associated with the benefits of risk management into four groups: probability and size of loss, risk capacity, costs of financial distress and managerial incentives. We now focus on the first three categories since we described the role of managerial incentives above. Firms with higher probability and size of loss have higher value of risk transfer. Probability and size of loss is related to the type of product, which varies by industry, and to the number of units sold, which is related to sales.

¹⁴ Data to estimate product liability claim probability and expected losses are difficult to acquire. Studies suggest that product liability suits may result in significant losses. For example, [Dungworth \(1988\)](#) examines product liability suits from 1974 to 1986 and finds a majority of these suits target a small number of firms—specifically, 79 companies were lead defendants in 100 or more suits each. This indicates these claims are low probability, high loss events.

Risk capacity refers to the firm's ability to withstand a given size loss without going into financial distress. Firms with lower risk capacity have higher value of risk transfer, all else equal. Risk capacity is generally increasing in firm size such as overall size, product space size and financial resources. Market value is a general measure of firm size and risk capacity, as is total sales although sales is also related to product liability exposure as mentioned above. Product space size is related to the number and diversity of products. Measures of product size include the number of products or the number of business segments covered. Firms with fewer products or business segments are less diversified and less able to withstand a given loss.¹⁵ Risk capacity is lower for firms with higher costs of financing or less ability to pay for a loss. Firms with net operating loss carry forwards (NOLs) have higher costs of paying for a loss because they cannot carry current losses back to receive an immediate refund. Likewise, firms with fewer assets available—internal or external—are less capable of financing losses. This will be related to total assets, the availability of funds and the cost of external financing. Firms with higher debt-to-equity ratios will have lower availability of funds and higher cost of external financing. Having lower expected cash flows when external financing is costly increases the external financing costs. Firms whose stock returns exhibit high correlation with the market portfolio, or high beta firms, have cash flows that are more correlated with the market. These firms are expected to have less internal funds when external capital is also costly because the overall market is doing poorly. Thus these firms will also have lower risk capacity and higher value of risk transfer.¹⁶

Firms with higher costs of financial distress also have greater benefits from risk transfer.¹⁷ The costs of financial distress include the costs of foregone investment opportunities, the effects of failure to pay creditors and increased probability of bankruptcy. These costs are higher for firms with greater investment opportunities and less short term liquidity. Firms with a larger proportion of intangible assets such as reputation, R&D or NOLs face greater bankruptcy costs.¹⁸ Lastly, we note that while greater reliance on debt initially increases the costs of financial distress, firms with high leverage may actually have lower expected costs of financial distress following a large loss due to limited liability.

4. Data

We begin by identifying a group of firms that report being insured for product liability exposure just prior to the liability crisis. Following the liability crisis, some of these firms

¹⁵ If we compare two same size firms, the firm with more products will have less exposure. As the number of products increases the value of insurance decreases since risk exposure decreases and risk capacity increases.

¹⁶ 'Hot' and 'cold' markets for equity issues that are correlated with overall stock returns are well established. High stock returns typically result in a hot market for equity issues, reducing the indirect costs associated with this method of raising external capital. Interest rates on debt financing are generally lower when the stock market is higher.

¹⁷ Numerous papers discuss the costs of financial distress including [Mayers and Smith \(1982, 1990\)](#), [Stulz \(1996\)](#), [Smith and Stulz \(1985\)](#), [Froot et al. \(1993\)](#), and [Tufano \(1996\)](#).

¹⁸ Bankruptcy costs may be disproportionately higher for smaller firms providing another reason why smaller firms perceive greater benefits from hedging ([Altman, 1984](#) and [Weiss, 1990](#)).

state that they are no longer insuring product liability exposure while others report that they are still purchasing insurance. We examine the importance of the different risk-bearing incentives by estimating the probability of continuing to insure following the liability crisis as a function of pre-crisis firm characteristics.¹⁹ Then we examine the extent to which the two groups of firms rebalance their overall risk exposure through changes in firm characteristics five years following the liability crisis.

For inclusion in our sample a firm must report being insured for product liability risk prior to 1985. Among these firms, we then search for firms that report being ‘self-insured’ and those that report being insured after 1985. The term self-insurance refers to firms not buying insurance; that is, although the term refers to insurance these firms are retaining this risk. These searches were done with a keyword search of 10-K reports on the NAARS database.²⁰ This initial search yields 131 firms that report product liability self-insurance at some point and 110 firms that report they are insured for product liability exposure after also reporting that they insured product liability exposure prior to 1985. We limit our sample to firms that announce becoming self-insured after 1984 and before 1990 to focus our sample on the effects of the liability crisis.²¹ Thus, we define a dichotomous variable, *STILL_INSURE*, equal to 1 if the firm discloses that it has continued to purchase insurance and equal to 0 if the firm discloses it has not continued to purchase insurance.

Since we require stock returns and accounting data from the CRSP and COMPUSTAT databases, our final sample reduces to 55 firms who confirm that they maintain insurance against product liability and 60 firms for whom we could identify a date of self-insurance between 1985 and 1989.²² Table 1 reports the distribution of firms across industries as measured by 2-digit SIC codes (from COMPUSTAT) and across insurance status for our final sample. The firms are clustered in several industries: chemicals that are mostly pharmaceutical firms (SIC code 28), machinery (SIC code 35), transportation equipment (SIC code 37), and measuring instruments (SIC code 38).

We discuss our explanatory variables using the four categories of risk management benefits: probability and size of loss, risk capacity, costs of financial distress and managerial incentives. Variables and their definitions are summarized alphabetically in Table 2. The first set of variables control for the probability and size of loss. Exposure is measured by the natural log of sales scaled by total assets, *SALES*.²³ Exposure is increasing in sales, suggesting a positive expected sign but larger sales also indicates larger size, making the

¹⁹ All the firms finance product liability risk prior to 1985. In our analysis we assume that the price increases were of similar magnitude across firms. If the price cost markup increases differentially across firms, due to asymmetric information and adverse selection, we expect this to be correlated with industries, and control for by industry categories. If differential price-cost margin increases occur and are uncorrelated to industry, our results will be biased towards zero.

²⁰ We search for self-insurance within ten words of liability. We also search 10-K reports on Lexis–Nexis.

²¹ Eighty-six of the self-insured firms become self insured during the 1985–1989 period, with roughly 80% of the firms changing status in 1985 and 1986. The remaining 45 self-insured firms were dropped from the sample because of timing issues: 10 were already self-insured in 1984, three became self-insured after 1989 and the date of self-insurance could not be identified for 32.

²² We lost one insured and 18 self-insured observations from missing 1984 firm information and 8 self-insured observations due to an absence of 1989 firm data.

Table 1
Number of insured and self-insured sample firms by industry

Industry	SIC code	Continue insurance	Discontinue insurance
Construction	17	0	1
Food	20	0	1
Textiles	22	1	0
Paper	26	1	2
Printing & Publishing	27	1	1
Chemicals	28	9	21
Petroleum refining	29	0	1
Rubber & Plastics	30	3	1
Leather	31	1	0
Primary metals	33	1	0
Fabricated metals	34	2	0
Machinery	35	10	7
Electrical	36	3	2
Transportation equipment	37	3	7
Measuring instruments	38	13	10
Misc. manufacturing	39	1	1
Durable goods	50	2	1
Non-durable goods	51	1	3
Misc. retail	59	2	0
Auto services	75	0	1
Health services	80	1	0
Total		55	60

sign indeterminate. Two other variables measure dimensions of firm size and risk capacity. Overall firm size, *SIZE*, measured as the natural logarithm of total market value, and *SEGMENT*, measured by the number of business segments. We expect the probability of using risk transfer to be decreasing in *SIZE* and in the number of segments. In our estimation we examine the effect of the number of segments as well as the effect of no diversification, defined as having only one reported segment.

A second group of variables relates to risk capacity in terms of the ability to finance a loss. We determine tax status by *NOL*, a dichotomous independent variable that equals 1 if the firm has net operating loss carryforwards, 0 otherwise. We predict that a higher probability of using risk transfer for firms with *NOL* equal to one. Several variables control for the cost of external financing. *NO_DEBT* is a dichotomous independent variable equal to 1 if the firm has no debt, 0 otherwise, since we have a significant number of firms with zero debt. *DEBT/EQUITY* is the ratio of long term debt divided by total firm market value.²⁴ The expected costs of external finance relate

²³ A measure of units sold is not available, and insurers generally base the insurance on a measure of sales, as well. We also include four industry categories with indicator variables, controlling some for exposure differences across product types.

²⁴ This measure of leverage is also used by Geczy et al. (1997). Assuming that higher debt-to-equity ratios do not reflect greater debt capacity, we argue that firms with larger debt-to-equity ratios will have higher probability of financial distress but lower bankruptcy costs due to limited liability.

Table 2
Variable definitions and descriptions

Variable	Description
<i>BETA</i>	The coefficient on the value-weighted market index from the market model computed using daily stock returns for the fiscal year.
<i>CL/CA</i>	The ratio of current liabilities to current assets.
<i>DEBT/EQUITY</i>	Debt to equity measured as the ratio of the book value of long-term debt divided by the total firm market value.
<i>HIGH_CL/CA</i>	Ratio of current liabilities to current assets if the ratio of current liabilities to current assets is above the 75th percentile.
<i>MTB</i>	The market value less the book value of the firm's common equity divided by the total firm market value.
<i>NO_DEBT</i>	A dichotomous variable equal to 1 if the firm has no debt, and to 0 otherwise.
<i>NOL</i>	A dichotomous variable equal to 1 if the firm has net operating loss carryforwards, and to 0 otherwise.
<i>OptionsAll</i>	The number of all options outstanding in millions of shares.
<i>Opt_In</i>	The number of options outstanding in millions of shares which can be identified as clearly in-the-money from proxy statement information divided by total assets.
<i>Opt_Out</i>	The number of options outstanding in millions of shares which can be identified as clearly out-of-the-money from proxy statement information divided by total assets.
<i>Opt_Unclass</i>	The number of options outstanding in millions of shares which cannot be identified as either clearly in-the-money or clearly out-of-the-money divided by total assets.
<i>SALES</i>	The natural logarithm of total firm sales normalized by total assets.
<i>SEGMENT</i>	The number of segments in which the firm does business as reported by the firm. For firms without data, we set the number of segments to one.
<i>SharOwn</i>	The natural logarithm of the market value of common shares beneficially owned by officers and directors as a group divided by total assets.
<i>SIZE</i>	The natural logarithm of the firm total market value defined as the sum of market value of equity, book value of long-term debt and book value of preferred stock.
<i>Std_Residual</i>	The standard deviation of the residuals from the market model computed using daily stock returns for the fiscal year.
<i>Std_Return</i>	The standard deviation of daily stock returns for the fiscal year.
<i>STILL_INSURE</i>	A dichotomous variable equal to 1 if the firm disclosed in their annual report or 10-K that they had commercial product liability insurance, and to 0 if the firm disclosed that they began self-insuring their product liability during the period 1985–1989.

to the correlation of firm stock returns to the market, or *BETA*, measured as the coefficient on the market index from a market model. We expect a lower probability of using risk transfer for firms with no debt and for firms with lower beta. The predicted sign on the debt-to-equity ratio also depends upon the costs of financial distress effect, described below. If the risk capacity were the only effect, the predicted sign would be positive.

The third group of variables controls for the costs of financial distress. As mentioned above, *DEBT/EQUITY* affects both risk capacity and the costs of financial distress: for firms with higher debt-to-equity ratios the costs of financial distress will be increasing in the debt-to-equity ratio but the expected bankruptcy costs will be declining due to limited liability. The net effect of an increase in the debt-to-equity ratio is thus an empirical

question. The costs of financial distress will be greater for firms with greater reliance on other external credit, such as trade credit.²⁵ We measure reliance on short term liquidity as the inverse of the current ratio, the ratio of current liabilities to current assets denoted by CL/CA .²⁶ Lower liquidity increases the probability that a loss will lead to financial distress. Firms with higher CL/CA (lower current ratios) rely more on financing operations through working capital, such as trade credit.²⁷ The reliance on working capital increases the value of risk transfer since it assures suppliers and customers that the firm will not be unduly hurt by a claim. Another variable related to the costs of financial distress is the ratio of market to book value. We measure the ratio of market-to-book, MTB , as market value less book value normalized by total firm value.²⁸ This variable captures two aspects of the costs of financial distress, namely intangible assets and growth opportunities. Higher market value relative to book value indicates greater intangible assets and/or growth opportunities and thus higher costs of financial distress and higher value of risk transfer.

Finally, we include a group of managerial compensation variables to control for additional effects of managers' risk management incentives. We measure managerial ownership of firm stock as the natural logarithm of the market value of common shares owned by officers and directors normalized by total assets, $SharOwn$.²⁹ We expect managers with greater stock ownership to have greater exposure to firm risk and be more likely to choose to continue company insurance. Managerial incentives from options ownership is measured as the total number of options outstanding to officers and directors normalized by total assets, $OptionsAll$. We distinguish in-the-money options from other options since in-the-money options create incentives similar to stock ownership. Proxy statements indicate that a significant number of managerial options are in-the-money.³⁰ We decompose all managerial options outstanding into three groups:

²⁵ The correlation between the debt-to-equity ratio and the ratio of current liabilities to current assets is 0.464 (see Appendix B). Suppliers are sensitive to the possibility of not being paid and are unlikely to extend credit if the firm experiences financial distress. This increases the costs of financial distress for firms that rely on trade credit financing.

²⁶ We examined a slightly different measure of leverage, $(Current\ assets - Current\ liabilities)/(Total\ assets)$, and found no significant estimation differences with this measure. We also examined a measure of interest coverage defined as interest expense divided by earnings before interest, tax and depreciation. Since interest coverage is not monotonic in earnings because some firms in our sample experience negative earnings, we report our results using the ratio of current liabilities to current assets.

²⁷ The ratio of property, plant and equipment to market value of the firm, PPE , was also examined to control for the costs of financial distress as used in other research. This variable had no explanatory power for our sample.

²⁸ Since some firms report negative book value in 1989, it is difficult to interpret the effect of changes in the ratio of market value to book value ratio. However, our regression results do not change qualitatively if instead we use market-to-book ratio.

²⁹ We normalize by assets to control for the fact that managers from larger firms tend to receive larger share and option grants, but also tend to receive greater monetary compensation and thus have greater overall wealth.

³⁰ We do not have the exercise price of each option owned, but proxy statements often give a range of exercise prices.

- those clearly in-the-money, *Opt_In*,
- those clearly out-of-the-money, *Opt_Out*, and
- a group that cannot be determined, *Opt_Unclass*.

We expect that options and particularly out-of-the-money options will increase managerial preferences for bearing risk, while in-the-money options will have incentive effects similar to stock ownership and will increase the preference for purchasing insurance.

Table 3 presents sample statistics and illustrates several initial differences between firms that continue to purchase insurance and those that do not. Firms that purchase insurance are generally smaller in terms of total market value and report fewer business segments. A greater proportion of these firms have positive net operating losses. Those firms that purchase insurance have higher debt to equity ratios. Interestingly, managers of firms who continue to buy insurance own less firm stock and have fewer stock options outstanding. In terms of systematic and overall risk, the two groups appear similar as measured by the standard deviation of stock returns, or standard deviation of stock return residuals from a market model.

Table 3
Descriptive statistics as of end of fiscal year 1984
(Comparison of means between firms that continue to insure and those that do not)

Independent variables	Mean		Difference in means	<i>t</i> -statistic for difference in means ^a	<i>p</i> -value
	Continue insurance	Discontinue insurance			
<i>SIZE</i> *	4.36	4.86	−0.49	−1.32	0.095
<i>SEGMENT</i> *	1.70	2.25	−0.546	−2.22	0.014
<i>SALES</i>	1.33	1.32	−0.009	−0.055	0.956
<i>NOL</i>	0.26	0.15	0.109	1.44	0.077
<i>NO_DEBT</i> *	0.09	0.12	−0.024	−0.47	0.339
<i>DEBT/EQUITY</i> *	0.157	0.207	−0.050	−1.63	0.053
<i>BETA</i>	0.76	0.68	0.082	0.86	0.196
<i>CL/CA</i>	0.434	0.431	0.004	0.08	0.470
<i>HIGH_CL/CA</i>	0.234	0.152	0.082	1.24	0.11
<i>MTB</i>	0.316	0.285	0.030	0.45	0.328
<i>SharOwn</i>	−1.864	−2.338	0.474	1.48	0.071
<i>OptionsAll</i>	0.005	0.006	−0.001	−0.51	0.306
<i>Opt_In</i>	0.0006	0.0016	−0.0010	−0.96	0.828
<i>Opt_Out</i> *	0.0002	0.0015	−0.0013	−1.35	0.09
<i>Opt_Unclass</i>	0.0038	0.0027	0.0011	0.62	0.269
<i>Std_Return</i>	0.0262	0.0242	0.00197	0.84	0.203
<i>Std_Residual</i>	0.0253	0.0233	0.00196	0.82	0.206

Note. Variables are defined in Table 2.

^a *t*-tests are one-tailed tests with unequal variances that the mean for firms that insure is greater than the mean for firms that do not continue to insure, unless noted by an * where the inequality is reversed, or in the case of *SALES* and *Opt_Unclass* which are based on a two tailed test.

* Indicates a one-tailed *t*-test of whether the mean for insured firms is less than the mean for firms which do not insure.

5. Evidence: estimation results

We estimate the probability of purchasing insurance using a probit specification. We specify the probability of purchasing insurance as:

$$\Pr\{STILL_INSURE\} = f(SIZE, SALES, NOL, NO_DEBT, DEBT/EQUITY, \\ BETA, CL/CA, HIGH_CL/CA, MTB, SharOwn, \\ Opt_In, Opt_Out, Opt_Unclass, \text{Industry dummies}).$$

We control for industry effects for the four large industries in our sample: SIC code 28 (chemicals), SIC code 35 (machinery), SIC code 37 (transportation equipment), and SIC code 38 (measuring instruments).³¹ In our estimation we include a second measure of current liabilities to current assets, *HIGH_CL/CA*, which is the ratio of current liabilities to current assets if the ratio of current liabilities to current assets is above the 75th percentile of our sample.

Tables 4a and 5a present the results from this specification as a function of 1984 firm characteristics and industry classifications. Table 4a reports coefficient estimates varying particular leverage measures without managerial compensation variables, while Table 5a reports results with these variables. Missing managerial data reduces the number of observations in Table 5. Overall, our results are consistent with expectations and quite robust in terms of signs and statistical significance across specifications. Several variables, overall firm size, the ratio of debt-to-equity, market beta, and high current liabilities to current assets are of expected sign and statistically significant in almost all specifications. Although larger firms are significantly less likely to purchase insurance and the number of reported segments is higher for larger firms, the number of reported business segments does not directly affect the probability of purchasing insurance—when included the estimated marginal effect was not statistically significant.³² The presence of net operating losses has the predicted sign and is statistically different from zero when managerial variables are included while the no debt variable is statistically different from zero when managerial variables are excluded.

To provide a sense of the magnitude of these effects, Tables 4b and 5b report the change in probabilities associated with a one standard deviation change in the variables within sample. As some variables are likely related to each other, the change in probability of purchasing insurance was evaluated at mean values of six ‘representative firms’ calculated from the data. The six firm groups are based upon variations in the three categorical variables: *NO_DEBT*, *NOL*, and *HIGH_CL/CA* and exclude the two groups with no members—those with no debt (*NO_DEBT* = 1) and a high ratio of current liabilities to

³¹ In our reported regressions we do not report any results with the number of business segments, as the variable was never statistically significant when other size measures were also included.

³² Firms with above median size report 2.16 business segments on average, while those below median size, average 1.82 business segments. We included segments both as an additional regressor and interacted with other variables, particularly size. We examined the number of segments and an indicator for reporting one segment or more than one (this division roughly split the data). Neither variable had a significant estimated coefficient, nor did interactions with size.

Table 4a
 Probit estimation of the probability of continuing to insure

Independent variables	Predicted sign	A	B	C	D
Intercept		1.059* (0.562)	1.065* (0.569)	1.765*** (0.671)	1.417** (0.597)
SIZE		-0.156* (0.079)	-0.179** (0.082)	-0.161* (0.084)	-0.180* (0.083)
SALES		-0.096 (0.179)	-0.194 (0.191)	-0.182 (0.202)	-0.229 (0.194)
NOL		0.581* (0.349)	0.558 (0.351)	0.610* (0.367)	0.579 (0.360)
NO_DEBT	+	-0.906* (0.489)	-0.850* (0.492)	-1.171** (0.526)	-0.996** (0.501)
DEBT/EQUITY	-	-2.570*** (1.042)	-3.146*** (1.224)	-3.053*** (1.259)	-3.475*** (1.219)
BETA	?	0.723** (0.323)	0.669** (0.329)	0.650** (0.335)	0.642** (0.334)
CL/CA	+		0.937 (0.712)	-1.685 (1.338)	
HIGH_CL/CA	+			1.933** (0.847)	1.045** (0.455)
MTB	+	0.388 (0.470)	0.454 (0.473)	0.549 (0.493)	0.534 (0.484)
SIC Code 38	+	-0.527 (0.405)	-0.573 (0.413)	-0.779* (0.431)	-0.683 (0.423)
SIC Code 28		-1.313*** (0.422)	-1.369*** (0.422)	-1.518*** (0.442)	-1.457*** (0.432)
SIC Code 35		0.173 (0.412)	0.086 (0.418)	0.173 (0.427)	0.126 (0.422)
SIC Code 37		-0.964* (0.534)	-1.078** (0.550)	-0.942 (0.586)	-1.064** (0.569)
Pseudo R ²		0.171	0.177	0.212	0.202
% correctly predicted		64.04	65.18	65.18	66.07

Notes. Variables are defined in Table 2. Entries are estimated coefficients with standard errors in parentheses. Regressions in columns A, B, C, and D have 114, 112, 112 and 112 observations, respectively.

$$\text{Pseudo } R^2 \equiv \left(1 - \frac{\log \text{likelihood with all variables}}{\log \text{likelihood with intercept only}} \right).$$

* Significance at the 10% level.

** Idem., 5%.

*** Idem., 1%.

current assets ($HIGH_CL/CA = 1$). Tables 4b and 5b report the average change in probability and its standard deviation over the representative firms. For dichotomous variables, we calculate the change in probability as the variable goes from zero to one for representative firms where the value is zero. For example, the change in the probability of buying insurance from having positive *NOL* is the change in probability as *NOL* goes from zero to 1, averaged across the three representative firms with *NOL* = 0. We also consider ac-

Table 4b

Average implied change in probability of continuing insurance (from an increase of 1 standard deviation or a change from 0 to 1)

Independent variables	A	B	C	D
<i>SIZE</i>	-0.115 (0.009)	-0.133 (0.009)	-0.117 (0.013)	-0.132 (0.013)
<i>SALES</i>	-0.031 (0.002)	-0.062 (0.003)	-0.056 (0.007)	-0.072 (0.007)
<i>NOL</i>	0.225 (0.001)	0.217 (0.002)	0.233 (0.008)	0.222 (0.006)
<i>NO_DEBT</i>	-0.326 (0.022)	-0.290 (0.031)	-0.385 (0.052)	-0.318 (0.051)
<i>DEBT/EQUITY</i>	-0.152 (0.014)	-0.186 (0.016)	-0.176 (0.020)	-0.201 (0.022)
<i>BETA</i>	0.135 (0.012)	0.126 (0.012)	0.117 (0.021)	0.118 (0.017)
<i>CL/CA</i>		0.087 (0.007)	-0.093 (0.089)	
<i>HIGH_CL/CA</i>			*	0.086 (0.023)
<i>MTB</i>	0.052 (0.003)	0.060 (0.004)	0.070 (0.011)	0.069 (0.009)

For the variables *SIZE*, *SALES*, *BETA*, *CL/CA* and *MTB*, the change in probability is calculated as the mean change in probability for a one standard deviation increase, the standard deviation of the sample of results is in parentheses under the mean. The change in probability is averaged over six 'representative' firms where discrete variables are set at specified values and the other variables are set at sample means for the subset of firms with these characteristics. The six representative firms are:

- a firm with *NO_DEBT* = 1 (and *DEBT/EQUITY* = 0), *NOL* = 1 and *HIGH_CL/CA* = 0,
- NO_DEBT* = 1 (and *DEBT/EQUITY* = 0), *NOL* = 1 and *HIGH_CL/CA* = 0,
- NO_DEBT* = 0 (and *DEBT/EQUITY* > 0), *NOL* = 0 and *HIGH_CL/CA* = 0,
- NO_DEBT* = 0 (and *DEBT/EQUITY* > 0), *NOL* = 1 and *HIGH_CL/CA* = 0,
- NO_DEBT* = 0 (and *DEBT/EQUITY* > 0), *NOL* = 0 and *HIGH_CL/CA* > 0, and
- NO_DEBT* = 0 (and *DEBT/EQUITY* > 0), *NOL* = 1 and *HIGH_CL/CA* > 0.

There were no sample firms with both *NO_DEBT* = 1 and *HIGH_CL/CA* > 0, so no representative firms with those characteristics were included. For *NOL*, the change in probability is calculated as the change from 0 to 1 for the three cases where *NOL* = 0 for the representative firm. For *NO_DEBT*, we calculate average the change in probability as *NO_DEBT* changes from 0 to 1 and *DEBT/EQUITY* goes from the minimum nonzero value to zero for the four cases where *NO_DEBT* = 0.

* When both *CL/CA* and *HIGH_CL/CA* are greater than zero in column C, we change both variables simultaneously and report the total effect.

counting relationships between the variables in our calculations. To calculate the change in probability of insuring from having positive debt-to-equity to having no debt, we calculate the change in probability of insuring as the *NO_DEBT* variable goes from zero to one and the *DEBT/EQUITY* variable moves from the lowest value of debt to equity to zero. There is also a relationship between variables that measure the ratio of current liabilities to current assets. We summarize the effect of a one standard deviation change in the ratio of current liabilities to current assets in a single number. In specifications with both variables, we add the two effects together.

Table 5a

Probit estimation of the probability of continuing to purchase insurance including managerial incentives

Independent variables	A	B	C
Intercept	1.839 ^{***} (0.648)	2.043 ^{***} (0.710)	1.882 ^{***} (0.651)
SIZE	-0.215 ^{**} (0.108)	-0.280 ^{**} (0.117)	-0.284 ^{**} (0.117)
SALES	-0.245 (0.208)	-0.193 (0.222)	-0.229 (0.211)
NOL	0.914 ^{**} (0.396)	0.919 ^{**} (0.408)	0.913 ^{**} (0.404)
NO_DEBT	-0.688 (0.524)	-0.710 (0.568)	-0.604 (0.537)
DEBT/EQUITY	-3.869 ^{***} (1.290)	-3.311 ^{***} (1.340)	-3.529 ^{***} (1.299)
BETA	1.012 ^{***} (0.377)	0.978 ^{***} (0.379)	0.994 ^{***} (0.379)
CL/CA		-0.891 (1.461)	
HIGH_CL/CA	1.127 ^{**} (0.479)	1.617 [*] (0.898)	1.163 ^{**} (0.493)
MTB	0.144 (0.616)	0.470 (0.654)	0.421 (0.647)
SharOwn	0.135 (0.129)	0.048 (0.140)	0.064 (0.137)
OptionsAll	-32.813 [*] (17.124)		
Opt_In		-54.989 (46.429)	-58.511 (45.204)
Opt_Out		-173.475 [*] (104.614)	-173.704 [*] (104.014)
Opt_Unclass		-26.261 (18.189)	-26.936 (17.800)
Pseudo R ²	0.230	0.251	0.248
% correctly predicted	70.48	69.52	72.38

Notes. Standard errors are in parentheses. Regressions include indicator variables for SIC codes 28, 35, 37, and 38. The number of observations is 105. Pseudo R² as in Table 4a.

* Significance at the 10% level.

** Idem., 5%.

*** Idem., 1%.

As reported in Tables 4b and 5b, the change in probability of purchasing insurance due to a one standard deviation change in the variable or a change from 0 to 1 is quite consistent across specifications. In general, coefficient estimates that are statistically different from zero have the largest effects on the change in the probability. The exception is the no debt indicator whose effect on the change in probability falls by one third and becomes insignificant when managerial variables are included. Changes in the dichotomous variables for no debt and NOLs have the largest effect on the change in probability of purchasing insurance, an effect that is perhaps not surprising since the variables change from 0 to 1. As a firm moves from having positive debt to no debt, it would reduce the probability of purchasing

Table 5b

Implied change in probability of continuing to insure
(from an increase of 1 standard deviation or a change from 0 to 1)

Independent variables	A	B	C
<i>SIZE</i>	−0.150 (0.022)	−0.164 (0.060)	−0.168 (0.060)
<i>SALES</i>	−0.074 (0.013)	−0.050 (0.018)	−0.060 (0.021)
<i>NOL</i>	0.343 (0.011)	0.344 (0.014)	0.343 (0.013)
<i>NO_DEBT</i>	−0.190 (0.078)	−0.207 (0.084)	−0.169 (0.073)
<i>DEBT/EQUITY</i>	−0.213 (0.026)	−0.158 (0.057)	−0.169 (0.060)
<i>BETA</i>	0.177 (0.050)	0.155 (0.057)	0.158 (0.056)
<i>CL/CA</i>	0.027 (0.046)	−0.029 (0.066)	
<i>HIGH_CL/CA</i>		*	0.080 (0.050)
<i>MTB</i>	0.018 (0.004)	0.052 (0.019)	0.047 (0.017)
<i>SharOwn</i>	0.082 (0.020)	0.026 (0.009)	0.035 (0.012)
<i>OptionsAll^H</i>	−0.133 (0.020)		
<i>Opt_In</i>		−0.092 (0.033)	−0.098 (0.035)
<i>Opt_Out</i>		−0.250 (0.094)	−0.252 (0.094)
<i>Opt_Unclass^H</i>		−0.076 (0.028)	−0.079 (0.028)

Notes. For the variables *SIZE*, *SALES*, *BETA*, *CL/CA*, *MTB*, *SharOwn*, *OptionsAll*, *Opt_In*, *Opt_Out*, and *Opt_Unclass* the change in probability is calculated as the mean change in probability for a one standard deviation increase, the standard deviation of the sample of results is in parentheses under the mean. See notes in Table 4b.

* When both *CL/CA* and *HIGH_CL/CA* are greater than zero in column B, we change both variables simultaneously and report the total effect.

insurance by 29 to 38% when managerial variables are omitted, the largest implied change in the probability of purchasing. This remains one of the largest effects after the inclusion of managerial variables even though its effect is reduced by about one third. Changing from no *NOL* to having an *NOL* increases the probability of purchasing insurance by 22 to 34%, with larger effects associated with specifications including managerial variables. These results suggest that the costs of financial distress are important factors in the decision to continue purchasing insurance.³³ Managerial incentives to bear risk are also important:

³³ Not all variables related to the costs of financial distress are equally important in the decision to purchase insurance. The effect on the probability of purchasing insurance of a change in our short-term liquidity measures

a one standard deviation increase in all options decreases the probability of buying insurance by about 13% while a one standard deviation increase in clearly out-of-the-money options decreases the probability of purchasing insurance by about 25%.

Variables related to the cost of external financing are also important factors in terms of the change in the probability of insuring. Increasing the debt to equity ratio by one standard deviation for firms who already have debt decreases the probability of purchasing insurance by 15 to 21%. Increasing the firm's stock correlation with the market by one standard deviation increases the probability of insuring by 12 to 17%. Increasing overall firm size by one sample standard deviation decreases the probability of insuring by 12 to 16%.

5.1. Long-run changes in characteristics

Firm policies and characteristics such as leverage, *NOLs*, size, reliance on working capital and managerial compensation are relatively fixed in the short run. However, over a longer period of time a firm should respond to a change in the cost of product liability insurance by rebalancing its overall risk profile. For example, Froot and Stein (1998) show that when hedging is costly, firms trade-off the extent of hedging with substitute activities such as holding more liquid capital and reducing exposure to illiquid risks. In our context, we might expect firms to adjust elements of their capital structure and product market decisions as well as their insurance decisions to reflect the changed environment. We now investigate whether firms appear to make other adjustments that change their risk exposures or risk-bearing capabilities after the decision to cease or continue hedging product liability exposures.

In Table 6 we compare the levels of risk bearing variables and changes in these variables after five years for firms that continue to purchase product liability insurance and those that do not. We chose the five year period to ensure a sufficient time to adjust to the change in risk-management strategy. As seen in Table 6, the experience of the two groups differs significantly in some dimensions. Firms that continue to purchase product liability insurance grew less in terms of overall size but grew more in terms of sales (normalized by assets). Firms that continue to purchase insurance had a lower increase in our proxy for market to book value. Some of these findings no doubt reflect the complementarity of different firm characteristics for risk bearing, similar to that observed by Petersen and Thiagarajan (2000) where firms that hedge and those that do not hedge the price of gold exhibit systematic differences in other firm characteristics, as well.

Firms that continued to finance product liability risk were generally more similar to firms who did not after five years than at the end of 1984.³⁴ Significant differences arise in two areas, however, that were not there in 1984. Firms that continue to buy insurance are significantly less likely to have no debt five years later. The other difference is the change

is relatively smaller across specifications and tends to vary considerably depending upon where the change is evaluated. When *CL/CA* and *HIGH_CL/CA* are both included, the estimated change in probability is negative.

³⁴ For characteristics that affect the insurance choice but are not affected by it we would expect to observe the greatest difference in characteristics at the point the self-insurance choice was made. Since 80% of the sample makes that choice in 1985–1986, we would expect a larger difference in 1984 than in 1989.

Table 6
Descriptive statistics as of end of fiscal year 1989

Variable	Mean		<i>t</i> -test for difference in means ^a	<i>p</i> -value
	Continue insurance	Discontinue insurance		
Comparison of mean levels, firms that continue to insure and those that do not five years out				
<i>SIZE</i>	4.76	5.53	−1.82	0.07
<i>SEGMENT</i>	1.73	1.85	−0.59	0.55
<i>SALES</i>	1.36	1.22	1.05	0.30
<i>NOL</i>	0.4	0.32	0.93	0.36
<i>NO_DEBT</i>	0.036	0.13	−1.90	0.06
<i>DEBT/EQUITY</i>	0.28	0.29	−0.084	0.93
<i>BETA</i>	0.54	0.57	−0.26	0.80
<i>CL/CA</i>	0.61	0.49	1.16	0.25
<i>MTB</i>	0.29	0.36	−1.10	0.28
<i>SharOwn</i>	−4.35	−4.58	0.61	0.55
<i>OptionsAll</i>	0.0095	0.0012	1.88	0.18
<i>Std_Return</i>	0.037	0.027	2.10	0.04
<i>Std_Residual</i>	0.037	0.027	2.14	0.04
Comparison of changes over the 1984–1989, firms that continue to insure and those that do not				
Δ <i>SIZE</i>	0.41	0.67	−1.63	0.11
Δ <i>SALES</i>	0.053	−0.11	1.94	0.06
Δ <i>NOL</i>	0.13	0.17	−0.40	0.69
Δ <i>NO_DEBT</i>	−0.055	0.017	−1.09	0.28
Δ <i>DEBT/EQUITY</i>	0.11	0.08	0.76	0.45
Δ <i>BETA</i>	−0.22	−0.11	−0.80	0.43
Δ <i>CL/CA</i>	−0.083	0.081	−0.60	0.55
Δ <i>MTB</i>	−0.019	0.077	−1.45	0.15
Δ <i>SharOwn</i>	−0.70	−0.19	−1.51	0.14
Δ <i>OptionsAll</i>	0.0062	−0.00043	1.40	0.18
Δ <i>Std_Return</i>	0.011	0.0032	2.20	0.03
Δ <i>Std_Residual</i>	0.011	0.0032	2.28	0.02

Notes. Variables are defined in Table 2. The change in a variable over the period is calculated as the 1989 value less the 1984 value.

^a *t*-tests are tests for differences in means with unequal variances.

in overall firm risk for the two groups over the five year period. Risk, as measured by the standard deviation of stock returns or the standard deviations of residuals from a market model, increased significantly more for the firms who continued to insure. While these measures were similar across the two groups in 1984, by 1989 the group that insured had higher risk measured by these variables. Assuming that this change in risk does not reflect an anticipated exogenous shock, this decrease in risk suggests that the firms that chose to self insure changed operations to become less risky. Systematic risk, as measured by beta, decreased for both groups but more for the insured group, although this difference is not significantly different from zero. This finding is also consistent with the insured group becoming more risky in that these firms exhibited higher systematic risk in 1984 as shown in Table 3. Overall, firms that insure appear to bear greater risk than those that do not insure five years after the decision whether to continue insurance coverage. Our findings on the other risk-bearing variables are supportive of this notion, but we do not observe differences across the board in these other measures.

6. Discussion and conclusion

This paper examines firms' decisions about continuing to purchase product liability insurance in response to a significant increase in the price of that insurance. We find that firms with greater risk bearing capacity and lower costs of financial distress are less likely to continue purchasing product liability insurance. In particular, firms with no debt, firms without net operating loss carryforwards, large firms and firms whose expected costs of external financing are lower because their cash flows are less correlated with external financing conditions are less likely to buy insurance. We also find an additional effect of managerial preference on the decision to purchase insurance: firms whose managers hold more options as compensation are less likely to purchase insurance and the effect is strongest for options that are identified as out-of-the-money. This might appear surprising as options place no value on the loss states where insurance makes a payment. However, it is precisely because options put no value on these states that managers holding options are less likely to prefer insurance that carries a premium with a positive mark-up.

Our specification allows for a non-linear effect of leverage on the decision to purchase insurance by estimating a separate effect for firms with no debt. This allows us to begin to disentangle two countervailing effects of leverage: higher costs of financial distress yield incentives for less risk taking while limited liability effects create stronger incentives for increased risk bearing. We find that firms with no debt are indeed less likely to purchase insurance, and significantly less likely to purchase insurance than firms with low levels of debt. As the level of debt to equity rises the chance that a product liability loss will result in the liquidation of the firm increases, and because of limited liability the proportion of the potential loss paid out by the equity holders decreases.

The sample design allows comparison of firms immediately before and several years after a sudden, significant increase in the price of product liability insurance and their subsequent risk transfer decisions. While differences remain among the risk-bearing characteristics of the insuring and non-insuring groups, the most significant finding is the substantial increase in relative risk displayed by firms purchasing product liability insurance as measured by the increased standard deviation of stock returns, increased market model residuals, and decreased number of firms with no debt. We hypothesize that these changes in risk result from policy decisions across firms in diverse industries that are not quantifiable with few variables. As a result of these decisions, the overall risk bearing increases for firms that continue to insure product liability risk relative to those that do not.

Our model of corporate risk management highlights some key differences between this investigation of product liability exposure and research examining the use of derivatives. Product liability exposure is a low probability, high loss event while changes in firm value from risk exposures due to interest rate and exchange rate changes tend to be more frequent and less severe. While firms can limit the expected impact from product liability risk on value through risk control and risk transfer, the two actions are not perfect substitutes, and neither action can fully hedge firm value. In contrast, losses from general exchange rate and interest rate exposure can be fully offset either by risk control or by risk transfer, and the two actions are likely to be perfect substitutes. Thus, although only firms' risk transfer decisions are observable in this study as well as in prior studies on use of derivatives, the effect of the unobserved risk control behavior will be more limited in our analysis.

Our results contrast with those from the derivatives literature in several ways. We find that firm size decreases the chance of purchasing insurance (corresponding to not hedging) whereas bigger firms use derivatives more. We separate the effects of high leverage and limited liability on the costs of financial distress. While previous studies have not made this distinction, our setting has more power to detect the limited liability effect given the relatively large nature of a product liability claim. We find that firms with low costs of financial distress, due to either high leverage or extremely low leverage, are more likely to discontinue their purchase of product liability insurance. In our study, no significant differences arise between firms based upon tangible and intangible assets, such as plant, property and equipment and R&D spending, although these have explanatory power in the prior literature on derivatives' use.³⁵ One possible explanation is that firms' cash flows tend to be naturally hedged by tangible and intangible investments, but not by product liability risk (cash flows are low when claims are high). When future investment opportunities are linked to current products, if those products are hurt by liability claims, the value of these opportunities will also be reduced.

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Appendix A. The effects of managerial compensation on risk bearing incentives

Risk-averse managers have incentives to reduce their firm's exposure to risk. In general, a manager is not well-diversified with respect to firm risk since his human capital, as well as financial capital, is tied to the firm's performance. Thus a risk-averse manager may use hedging to reduce his exposure to firm risk even if it does not increase firm value. Compensation that is convex in firm value such as stock options or bonus plans creates a possible countervailing effect. For example, Smith and Stulz (1985) and Tufano (1996) show that managers with convex compensation schemes may prefer to leave firm exposures unhedged. Both papers consider the case where hedging symmetrically reduces the variance of firm value, and the case where the cost of the hedge does not affect the expected value of the firm.

Our analysis explores incentives for corporate hedging when hedges are *asymmetric* as with insurance contracts or options that primarily limit downside risk but not upside outcomes. Risk-averse managers' incentives to use asymmetric hedges are complicated. With asymmetric hedges, managers with options will vary in their preference for hedging depending upon the probability of the loss event, the magnitude of the loss and the exercise

³⁵ Earlier versions of this paper included these variables in the estimation, but they were dropped as they had no effect on the probability of purchasing insurance.

price. The price of the hedge will also affect the decision whether the price is equal to the present value of the expected loss or includes a mark-up as well.

To illustrate the effects, consider a manager with concave utility function $U(w)$ where w is managerial compensation. The manager's compensation is composed of a fixed fee, A , plus a bonus should the firm value, F , exceed a stated level, X . Firm value has two components. One is the present value of the firm's cash flows, V , and the other is a significant loss, L , which has a binomial distribution on $(0, \bar{L})$. In the absence of hedging, the manager's compensation is $w = A + \max\{X - F, 0\}$ and the value of the firm is $F = V - L$.

The loss risk can be hedged with insurance. The price of the insurance or premium, P , is a function of the expected loss and the mark-up, m . The firm insures a fraction $g \in [0, 1]$ of the loss. Therefore the value of the firm with insurance will be:

$$F = V - L + gL + g(1 + m)E[L].$$

The degree of insurance, g , will be chosen by the manager to maximize his expected utility. Expected utility for the manager can be written as

$$\begin{aligned} E[U(w)] &= E[U(A + \max\{X - F, 0\})] \\ &= \Pr\{F \leq X\}U(A) + \Pr\{F > X\}E[U(A + \max\{X - F, 0\}) \mid F > X]. \end{aligned}$$

The first-order condition with respect to g is

$$\begin{aligned} 0 &= \frac{\partial \Pr\{F \leq X\}}{\partial g} U(A) + \frac{\partial \Pr\{F > X\}}{\partial g} E[U(A + \max\{X - F, 0\}) \mid F > X] \\ &\quad + \Pr\{F > X\} \frac{\partial E[U(A + \max\{X - F, 0\}) \mid F > X]}{\partial g}. \end{aligned}$$

This equation highlights the difficulty in analyzing the incentives for asymmetric hedges. The hedge will affect the probability that the firm value is greater than the strike price, X . In addition, the hedge will affect the payout should the strike price be reached. The insurance hedge will decrease firm value (and hence the probability of the bonus) in non-loss states due to the premium payment. In the loss state, the insurance hedge will increase the probability of the bonus payment. The net effect depends upon the probability of loss, the magnitude of the loss, and the size of the premium.

Table A.1 presents a numerical example to illustrate some of these effects. This example follows the layout described above with the underlying value of cash flows from the business, V , distributed normally with mean 500 and variance 1000. In the "base case," the loss, \bar{L} , can occur with a probability of $p = 0.01$, with the loss value equal to $\bar{L} = 100$. A manager with power utility to the -0.5 is compensated with a fixed fee of 10 plus a bonus equal to $\max\{F - 500, 0\}$. The bonus is offered "at-the-money" similar to many executive options. For example, the manager may choose from four options: full insurance, 10% coinsurance, 20% coinsurance, and no insurance. In the base case insurance is fairly priced, that is, the mark-up is zero. To calculate expected managerial utility for each option, a distribution of firm values is constructed by combining 10,000 draws from the V and L distributions. We calculate managerial compensation and managerial utility for each of the 10,000 draws and report expected utility as the average over the 10,000 draws.

Table A.1
Expected utility

	Full insurance	10% coinsurance	20% coinsurance	No insurance
Base case	5.989	5.993	5.996	5.995
Changes in level of loss, \bar{L}				
$\bar{L} = 50$	6.006	6.007	6.009	6.005
$\bar{L} = 70$	5.999	6.001	6.009	6.000
$\bar{L} = 90$	5.993	5.996	5.999	5.996
$\bar{L} = 110$	5.986	5.990	5.993	5.993
$\bar{L} = 130$	5.980	5.984	5.988	5.991
Changes in probability of loss, p				
$p = 0.005$	6.006	6.007	6.009	6.009
$p = 0.015$	5.973	5.978	5.983	5.986
$p = 0.02$	5.957	5.964	5.970	5.976
$p = 0.025$	5.941	5.949	5.957	5.965
$p = 0.03$	5.925	5.935	5.944	5.953
Changes in markup over cost, m				
$m = 0.05$	5.989	5.993	5.996	5.995
$m = 0.1$	5.988	5.991	5.995	5.995
$m = 0.15$	5.986	5.990	5.993	5.995

As seen in the numerical example, managerial preferences move toward no insurance as the level of loss increases, the probability of loss increases, or the mark-up on insurance increases. For product liability insurance, loss events have low probability and high loss. Liability insurance typically also has a mark-up greater than zero. Under these conditions of high loss, low probability of loss, and positive mark-up over cost, managers with option or bonus compensation will generally prefer not to hedge.

Appendix B. Data appendix

Our data are defined in the text and Table 2. Here we provide greater detail on the variables we compiled from COMPUSTAT data, as well as Table B.1 of correlations among our continuous variables.

SIZE The natural logarithm of the sum of the firm total market value defined as the sum of market value of equity (COMPUSTAT data item 199 times COMPUSTAT data item 25), book value of long-term debt (COMPUSTAT data items 9 and 34) and book value of preferred stock (COMPUSTAT data item 130).

SALES The natural logarithm of total firm sales (COMPUSTAT item 12) normalized by total assets (COMPUSTAT item 6).

NOL A dichotomous variable equal to 1 if the firm has some net operating loss carry-forwards (COMPUSTAT data item 52), and to 0 otherwise.

NO_DEBT A dichotomous variable equal to 1 if the firm has no debt (COMPUSTAT data item 9 plus item 34), and to 0 otherwise.

Table B.1
Correlation table

Correlations for non-dichotomous variables, pre-1984 levels								
	<i>SIZE</i>	<i>SEGMENT</i>	<i>SALES</i>	<i>DEBT/EQUITY</i>	<i>CL/CA</i>	<i>MTB</i>	<i>SharOwn</i>	
<i>SEGMENT</i>	0.283	1						
<i>SALES</i>	0.077	-0.012	1					
<i>DEBT/EQUITY</i>	-0.173	0.190	-0.060	1				
<i>CL/CA</i>	-0.043	-0.038	-0.053	0.464	1			
<i>MTB</i>	0.182	-0.159	-0.143	-0.361	-0.086	1		
<i>SharOwn</i>	-0.513	-0.346	-0.044	-0.217	-0.136	0.418	1	
<i>OptionsAll</i>	-0.189	-0.123	-0.247	-0.125	-0.008	0.385	0.337	
Correlations with non-managerial variables (112 observations)								
	<i>SIZE</i>	<i>SEGMENT</i>	<i>SALES</i>	<i>DEBT/EQUITY</i>	<i>BETA</i>	<i>CL/CA</i>		
<i>SEGMENT</i>	0.2763	1						
<i>SALES</i>	0.0137	-0.0228	1					
<i>DEBT/EQUITY</i>	-0.1523	0.2357	0.0104	1				
<i>BETA</i>	0.4749	-0.0136	-0.0059	-0.0658	1			
<i>CL/CA</i>	0.1185	0.2174	0.3588	0.4806	0.1107	1		
<i>MTB</i>	0.2068	-0.1558	-0.1904	-0.3574	0.2884	-0.2682		
Correlations with managerial variables (105 observations)								
	<i>SIZE</i>	<i>SEGMENT</i>	<i>SALES</i>	<i>DEBT/EQUITY</i>	<i>BETA</i>	<i>CL/CA</i>	<i>MTB</i>	<i>SharOwn</i>
<i>SEGMENT</i>	0.2656	1						
<i>SALES</i>	0.0432	-0.0151	1					
<i>DEBT/EQUITY</i>	-0.1742	0.2256	-0.0045	1				
<i>BETA</i>	0.4584	-0.029	0.0219	-0.0657	1			
<i>CL/CA</i>	0.1121	0.2075	0.3517	0.4594	0.1243	1		
<i>MTB</i>	0.2339	-0.1358	-0.1653	-0.3346	0.301	-0.2285	1	
<i>SharOwn</i>	-0.4876	-0.3347	-0.0504	-0.1802	-0.1904	-0.3923	0.4197	1
<i>OptionsAll</i>	-0.2182	-0.1349	-0.2366	-0.1526	0.1488	-0.1799	0.278	0.2846

Notes. All variables are defined in Table 2.

CL/CA The ratio of current liabilities (COMPUSTAT data item 5) to current assets (COMPUSTAT data item 4).

MTB The market value (COMPUSTAT data item 199 times item 25) less the book value of the firm's common equity (COMPUSTAT data item 60) divided by the total firm market value as defined under the variable *SIZE*.

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