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Introduction

Kenneth A. Froot

In recent years, the magnitude of catastrophic property-casualty disaster risks has become a major topic of debate. The insurance industry now regularly discusses potential U.S. earthquake or hurricane losses of $50–$100 billion, a magnitude of loss that was unthinkable ten years ago. The disasters of Hurricane Andrew and the Northridge Earthquake alone totaled over $45 billion in 1997 dollars, with the insured component running to almost $30 billion. This compares with cumulative insured losses from natural catastrophes in the decade prior to those events (roughly 1980–92) of only about $25 billion (according to data from Property Claims Services).

These enormous increases in potential losses are likely to be permanent and even to increase over time. During the period 1970–90, the population of the Southeast Atlantic coastal counties increased by nearly 75 percent, a rate almost four times that of the nation as a whole. Annual growth rates in population per square mile in California and Florida have been two or three times the national average for the last three decades (Lewis and Murdock, chap. 2 in this volume). Indeed, analysis by Guy Carpenter and Co. suggests that, because of

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This introduction expounds on the collection of papers written for this volume and the conference, "The Financing of Property Casualty Risks," organized by the author under the auspices of the National Bureau of Economic Research and its Insurance Program.

The author is deeply indebted to many individuals for their comments and help, particularly many NBER conference participants, too numerous to mention. He has particularly benefited from conversations with Clem Dwyer, Peter Diamond, Marty Feldstein, David Govrin, Chris McGhee, Roberto Mendoza, Brian Murphy, Paul O'Connell, Steve Ross, Jeremy Stein, Gordon Stewart, and Joe Umansky. He also thanks Howard Kunreuther, David Moss, Frank Pierson, and George Segelken for detailed and extremely helpful comments on this essay. Thanks go as well to the NBER's Insurance Program sponsors, the sponsors of the Global Financial Systems Project at Harvard Business School (HBS), and the Department of Research at HBS for generous research support. Responsibility for any errors or omissions lies solely with the author.

growth in hazard-prone areas since 1950, real-dollar damages of a given-size natural event have been doubling every fourteen years.

With prospective event losses that can easily exceed $50 billion, it would appear that the insurance industry is not ready for a major event. The capitalization of the bearers of catastrophe risk is a major problem. Estimates (from the A. M. Best Co. as of 30 September 1996) of total capital and surplus of U.S. insurers run to about $239 billion. While a large natural disaster would not bankrupt the entire industry, this capital and surplus apply to *all* risks (property-casualty, liability, worker's compensation, etc.), not just catastrophes. A large event could, therefore, place firms' capital under severe stress, potentially jeopardizing the rewards of both policyholders and investors.

Traditionally, the insurance industry has avoided these financial stresses by pooling its exposures for large events. This occurs through reinsurance treaties with separately capitalized reinsurers. Insurers can pass along the risks of low-probability, high-cost events to these reinsurers, who accomplish the pooling. The pass-through is, however, only partial. Very little of the reinsurance in place provides protection against industrywide losses for catastrophic (cat) events greater than $5 billion. That is, for a $50 billion cat event, the overwhelming majority of the last $45 billion of losses (after the first $5 billion) is not covered by reinsurance. In a narrow sense, this is not surprising, given the relatively small capital and surplus of the reinsurance industry ($26.7 billion for U.S. reinsurers, $6.5 billion for Bermudan reinsurers, $7.0 billion for German reinsurers, and $16.8 billion for others) (Guy Carpenter 1997). Thus, at present levels of capital, the worldwide reinsurance industry is not capable of funding large-event risks in the United States, let alone the rest of the world.

The paucity of reinsurance protection at high layers of exposure can be observed directly from reinsurance-buying patterns. To do this, I assembled data on property-casualty contracts brokered by Guy Carpenter. These data cover a large fraction of all catastrophe-reinsurance purchases by U.S. insurers.[1] From them, it is possible to gain a sense of the paucity of reinsurance coverage at high levels of losses. Figure 1 shows the relation in these data between the fraction of pooled insurer exposure covered by reinsurance and the size of industrywide events.[2]

1. Catastrophe-reinsurance contracts oblige the writer to pay the cedent insurer for its insurance losses associated with a natural hazard. The contracts are typically in an "excess-of-loss" form. This means that the writer is obliged to pay up to a fixed-limit amount for all losses in excess of a given deductible ("retention"). To see how such contracts work, consider an insurer that purchases a layer of reinsurance covering $100 million in cat losses in excess of $200 million. These terms imply that, if the insurer's losses from a single catastrophic event during the contract year exceed $200 million retention, the layer is triggered. The reinsurer pays the insurer the amount of any losses in excess of $200 million, with the loss capped at a limit of $100 million. By purchasing this contract, the insurer cedes its exposure to single-event catastrophe losses in the $200–$300 million range. In return for assuming this exposure, the reinsurer receives a premium payment. If the insurer wishes to cede a broader band of exposure, it could purchase additional layers—$100 million in excess of $300 million, $100 million in excess of $400 million, and so on.

2. The procedure for attaching individual reinsurance-contract layers to industry losses is described in Froot and O'Connell (chap. 5 in this volume).

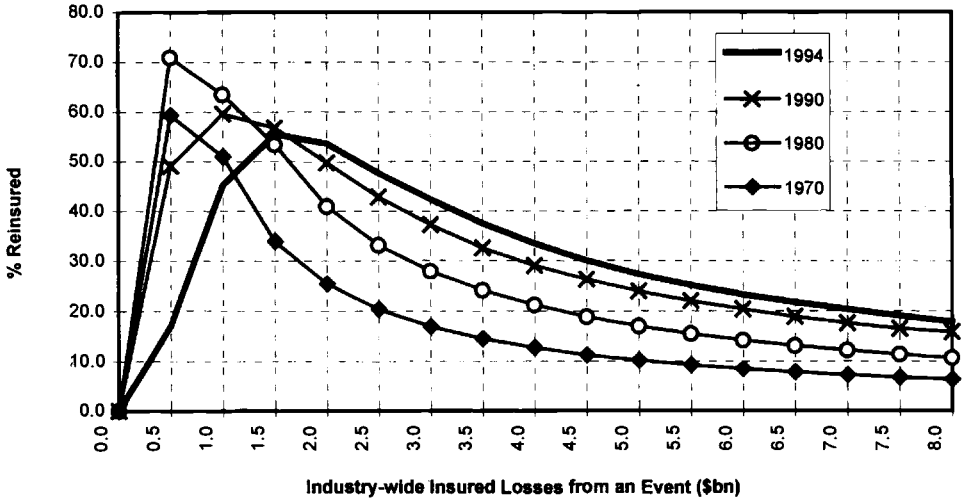

Fig. 1 Percentage of exposure that insurance companies reinsure (by various event sizes)

Note: Event losses are given in 1994 dollars and are adjusted for changes in demographics and GNP.

There are two important points to be made from figure 1. First, reinsurance coverage as a fraction of exposure declines markedly with the size of the event, falling to a level of less than 30 percent for events of only about $5 billion.[3] Clearly, only a small fraction of large-event exposures is covered, and, remarkably, this figure *overstates* that fraction. That is because the only insurers included in the data are those that actually purchase reinsurance.[4] The implication is that insurance companies overwhelmingly retain, rather than share, their large-event risks.

This point must be expanded in one important respect. Many exposures faced by the corporate and household sectors are self-retained and *never even reach insurers in the first place*. Corporations, for example, tend to self-insure, particularly against large losses—even while purchasing insurance against small losses. One study documents that insurance coverage is extremely limited for corporate cat losses of between $10 and $500 million (for a single corporation) and virtually nonexistent for losses above $500 million (Doherty and Smith 1993). This suggests that the vast majority of primitive cat risk in the economy is being retained. The implication is that the problem of inadequate risk sharing—and the failure of the reinsurance sector to help accomplish it—is on a far larger scale than can be directly indicated by figure 1.[5]

3. Indeed, the figure shows that 30 percent is an improvement over the past. In 1970, coverage of similar event sizes was less than 20 percent.

4. For firms that did buy reinsurance and are in the database, I observe the entire reinsurance program.

5. Of course, some types of risk are subject to asymmetrical information or manipulation, and the resulting adverse selection or moral hazard makes sharing them inherently problematic. I dis-

There is a second, more subtle point to be taken from figure 1. It is apparent that, after a large event, like Hurricane Andrew in 1992, retentions (or "deductibles") tend to increase. After an event, the total amount of coverage does not rise (indeed, it appears to fall somewhat). Most of the action is that a typical firm's window of coverage shifts toward higher layers of protection. In other words, coverage for large events apparently increases only at the expense of coverage for small events. I return to this point in the discussion below.

It is striking that so little reinsurance is in place for large-event losses. After all, it is large events whose risks need most to be shared. This paucity of risk sharing is costly for two reasons. First, poor risk sharing means that individuals bear higher portfolio risks. With higher portfolio risk, hurdle rates for new investments are higher, and, therefore, investment spending is lower, than if risk sharing were perfect.

There is a second cost that makes hurdle rates higher and investment lower. This comes from ex post burden sharing. Ex post burden sharing occurs when those who bear risk try to get someone else to pay their losses. This behavior is costly because it creates bad incentives. If someone else will pay, then risk-increasing investments are subsidized, while risk-reducing investments, such as mitigation, are taxed. For example, homeowners overbuild on exposed coastline because of subsidized insurance rates or because they expect to be bailed out by a government program; insurers are tempted to take too much risk relative to their capital, thereby shifting part of the cost of disasters onto other insurers, state agencies, and insurance customers; and some households and companies decline to purchase sufficient insurance, under the assumption that they will receive de facto protection. Bad incentives increase the aggregate level of risk. They also further worsen its distribution, as those with the greatest cat risks have the greatest marginal incentive to take more on.

It is not my goal here to gauge the magnitude of these costs. But both these mechanisms raise costs of capital and reduce economic growth. While the link between lower capital costs and higher growth rates is not well established, it is worth noting that lowering capital costs by enough to spur even a single basis point of additional growth is worth $700 million per year in a $7 trillion economy such as that of the United States.

The discussion below takes as its central premise the argument that the system of redistributing large catastrophe risks has not spread risks into and beyond insurer balance sheets and out evenly across investors. The discussion also takes as given that there are large costs associated with an equilibrium in which risk sharing is inefficient. I then go on to ask whether the current framework for managing cat risk is functioning as well as is possible. What barriers (if any) prevent higher-layer risks from being spread and/or mitigated? Are the capital markets likely to solve the problem?

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cuss this issue below. For now, however, it is sufficient to note that catastrophe events—so-called acts of God—are basically exogenous to mankind. These risks (as opposed to, say, liability risks) are, therefore, relatively free from asymmetrical information and moral hazard.

These are the issues that motivate this volume and the papers in it. The objective of the volume is to facilitate a better understanding of the issues and to serve as a starting point for serious discussion among practitioners, academics, and policymakers about the basic problems.

In what follows, I enumerate eight different explanations for barriers to better risk sharing. These explanations serve as ways of introducing the ideas of each chapter and set of panelist comments. Naturally, one's view of the solution to the problem of inadequate catastrophic risk sharing depends on the assumed cause. The introduction then turns to solutions that have been suggested, many during the conference itself, with a focus on the role of the capital markets and alternative means of redistributing cat risk.

Explanations for the Paucity of Catastrophe Risk Sharing

Explanation 1: Prices of Catastrophe Reinsurance Are High because of Insufficient Reinsurance Capital

This explanation relies on the premise that prices are high. Thus, before evaluating the sufficiency of reinsurance capital, we must first examine whether reinsurance prices are high relative to some natural benchmark. A comparison of actual prices with a benchmark that somehow represents fair prices is a useful indicator. For the sake of argument, I assume that fair prices are those that would prevail if the system for redistributing cat risk were perfect and frictionless. In such a system, catastrophe-risk prices would be determined by investors. This makes sense because it is investors who, in one form or another, must ultimately provide catastrophic risk–bearing capacity.

As is generally argued by both practitioners and financial economists, investors require relatively low average returns for bearing risk exposures that provide large diversification benefits. Take, for example, investments that are a small part of total wealth and that are uncorrelated with the returns on other forms of wealth (such as stocks and bonds). Such investments improve the reward-to-risk ratio of investor wealth as long as their average returns exceed the return on risk-free investments like U.S. Treasury bills. This suggests that the (relatively low) short-term U.S. Treasury rate is the threshold required return for a small, uncorrelated investment.

Historical data suggest that catastrophe risk is one such investment since returns from bearing cat risk through reinsurance contracts are uncorrelated with all other major investor asset classes.[6] If this is true, then, with wide risk distribution, the fair catastrophe premium on a reinsurance contract is just the actuarial contract loss. In other words, the contract premium should equal actuarial insurer losses covered by the reinsurance contract. Of course, actuarial

6. See Froot et al. (1995), which presents data showing that recent returns from bearing catastrophe risk are uncorrelated with other major financial asset classes, such as U.S. and foreign stocks and bonds as well as currencies.

losses are not known with certainty. One can only estimate actuarial losses. Nevertheless, as long as the estimate of expected loss is unbiased and the uncertainty in actuarial losses is itself uncorrelated with investor wealth, then the premium should on average equal estimated actuarial losses.

To those in the industry, it comes as no surprise that reinsurance premiums are today considerably greater than estimates of actuarially expected losses covered by reinsurance. A good and very visible example is the recent purchase of reinsurance by the California Earthquake Authority (CEA) from National Indemnity, a subsidiary of Berkshire Hathaway. Under the structure of that contract, National Indemnity receives an annual premium that exceeds actuarially expected losses by 530 percent. To see this, note that the average annual premium for the four-year aggregate cover is 10.75 percent of the annual limit, whereas the likelihood that the reinsurance is triggered is 1.7 percent or (10.75/1.7) − 1 = 530 percent (according to EQE International, a catastrophe-risk-modeling firm). In other words, Berkshire Hathaway has a 1.7 percent chance per year of losing the $1.05 billion it has put up; in return, it receives $113 million per year in premiums. Indeed, under the contract specifications, Berkshire Hathaway receives four years' worth of premiums in the first two years. Since the $1.05 billion cover aggregates over the four-year period, Berkshire Hathaway is effectively putting up about $600 million in net exposure for a 93.4 percent chance to make about $400 million in premium.[7]

The pricing of this contract is, in today's market, not unusual. Historically, reinsurance-contract premiums have exceeded actuarial contract losses by large amounts. Figure 2 shows a computation of the percentage excess of premiums over expected losses. While a multiple of five appears relatively high by the standards of the early 1980s, prices are on average nearly that high since Hurricane Andrew. In many instances, the prices are greater than those shown in figure 2, which averages across both high and low reinsurance layers. In general, the multiples on low-probability, higher layers (such as the CEA tranche) have been particularly high (see fig. 3), the more so since Hurricane Andrew.

Once reaction to the Berkshire Hathaway example and the numbers shown in figure 2 is healthy skepticism. The computations require one to measure actuarial value, which is not really possible. The actuarial values behind the figure are derived from the historical distribution of catastrophe losses.[8] And this historical distribution is likely to differ from what market participants considered to be relevant at various times. Indeed, a portion of what appears to be a secular increase in prices in figure 2 may actually be attributable to increasingly large losses expected by the market.

7. Based on a probability of 1.7 percent per year, the chance of no event over the four years is $(98.3\%)^4 = 93.4\%$. Data in this paragraph are from *IBNR Insurance Weekly* (Dowling and Partners Securities) (vol. 3, no. 46) and from remarks by Richard Sandor.

8. For a description of how these numbers are calculated, see Froot and O'Connell (chap. 5 in this volume).

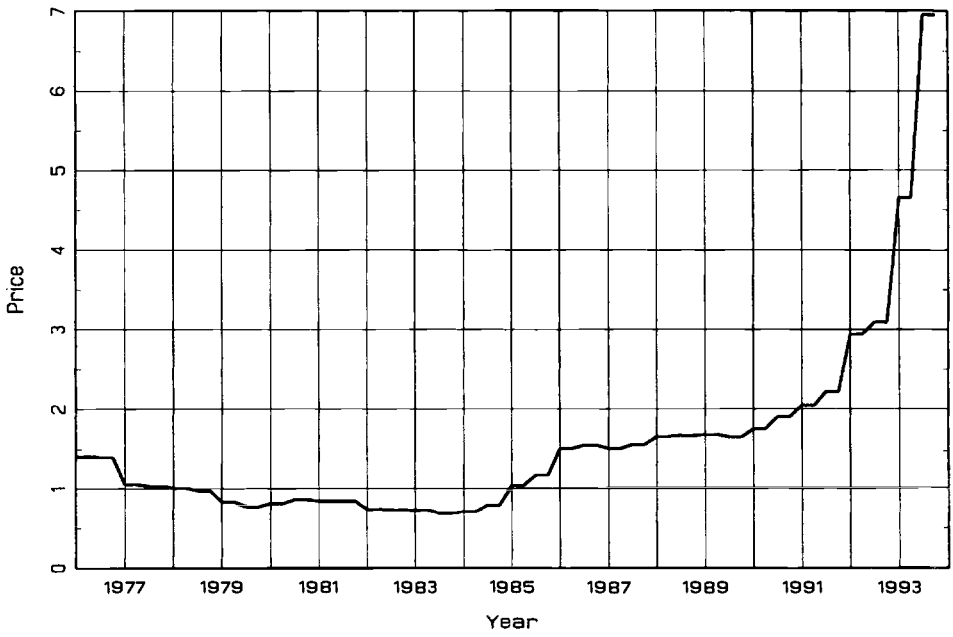

Fig. 2 Industry price per unit of ceded exposure

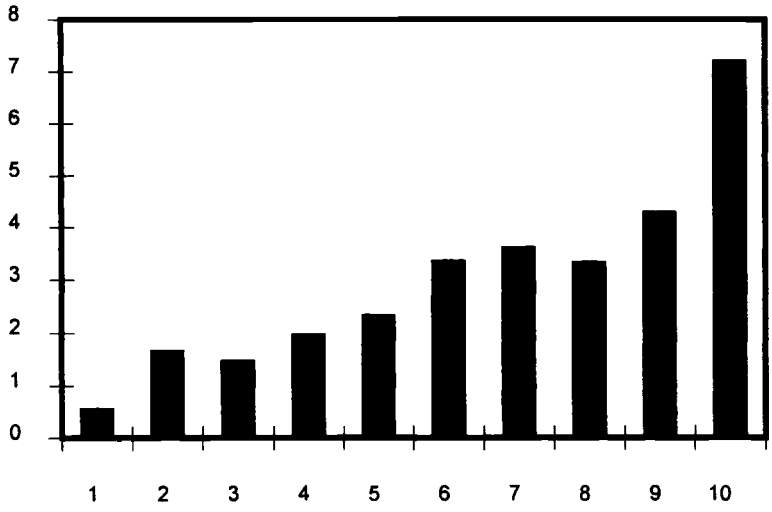

Fig. 3 Relation of price to attachment probability (layer 10 is highest retention)

However, none of this skepticism changes the fact that, while the numbers in the figure seem high by actuarial standards, they are not high by the standards of current market prices for catastrophe risk, at least as shown by the National Indemnity/CEA reinsurance layer. Indeed, Berkshire Hathaway shareholders appear to have rejoiced at having written the reinsurance: on the day the contract was announced, Berkshire's stock market valuation rose by over $400 million, or 1 percent, in excess of the broad stock market change. This suggests that shareholders saw the reinsurance contract (and those that might follow) as providing net present value.

With these arguments about catastrophe-reinsurance prices in mind, it is worth exploring the reasons why prices might indeed be too high. (Below, I also consider explanations that assume that current prices are fair.) The specific explanation considered in this section is that prices are high because catastrophic risk-taking capital is somehow limited. Even if such capital shortages are relatively temporary, they might exist for a number of structural reasons: it may be costly for existing reinsurers to raise additional funds in the capital markets; it may be hard to find investors and names who expect adequate rewards for bearing catastrophic risks; it may also be that it is costly for reinsurers to accumulate large amounts of collateral on their balance sheets.

Shortages of capital are an important rationale for Berkshire Hathaway's strategy in reinsurance. In his 1996 letter to shareholders in Berkshire Hathaway's annual report, Warren Buffett observes, "Our . . . competitive 3dvantage [in writing 'supercat' risks] is that we can provide dollar coverages of a size neither matched nor approached elsewhere in the industry. Insurers looking for huge covers know that a single call to Berkshire will produce a firm and immediate offering." Given that easy access by new and existing reinsurers to additional capital would remove this competitive advantage, it seems clear that Buffet believes in—and profits from—capital shortages.

Indeed, there is a perception that the shortage may become even worse once reinsurer capital is depleted by a large event. Again in Berkshire Hathaway's 1996 annual report, Buffett writes, "After a mega-catastrophe, insurers might well find it difficult to obtain reinsurance even though their need for coverage would then be particularly great. At such a time . . . it will naturally be [Berkshire's] long-standing clients that have first call on it. That business reality has made major insurers and reinsurers throughout the world realize the desirability of doing business with us. Indeed, we are currently getting sizable 'standby' fees from reinsurers that are simply nailing down their ability to get coverage from us should the market tighten." Buffett's entire discussion of "supercat" risks emphasizes the value to Berkshire's shareholders of the company's substantial financial capacity. In a world of no capital shortages, large capital capacity is nothing to write home about.

Are there more concrete facts to suggest that capital shortages are behind high prices? There are some. A second important feature of figure 2 is that prices appear to rise in the aftermath of major catastrophic events and then fall

Table 1 **Event Study of Hurricane Andrew**

	A. Southeast Exposure			B. Hurricane Exposure		
	Mean Exposure	Mean $\Delta\ln(p_{j,t})$	Mean $\Delta\ln(q_{j,t})$	Mean Exposure	Mean $\Delta\ln(p_{j,t})$	Mean $\Delta\ln(q_{j,t})$
5 most-exposed insurers	.707	.415	−.021	.918	.583	−.082
5 least-exposed insurers	.000	.335	−.013	.561	.336	−.047

Source: Froot and O'Connell (chap. 5 in this volume).

Note: Comparison of price responses in the year after Hurricane Andrew, for different insurers. Panel A contrasts insurers that have high and low exposure to the Southeast (as measured by market share). Panel B contrasts insurers that have high and low exposure to hurricanes. The table shows the mean exposure and the mean price change of the five most extreme contracts in each case. The mean price change for the insurers with lesser exposure to the Southeast is calculated using all fourteen of the insurers that have zero market share in that region.

afterward. This can be seen most clearly in the period around Hurricane Andrew (1992). Prices rose substantially in 1993 and have consistently fallen since. While the figure does not include 1995 and 1996 price data, preliminary estimates suggest that prices have fallen by approximately 27 percent during that time.[9]

It is perhaps not surprising that the price of reinsurance increases in the aftermath of an event since event losses are likely to raise the demand for insurance and reinsurance. Of course, one reason for an increase in demand is that capital and surplus are depleted and in short supply at the insurer level.[10] In a world of perfect markets, this depletion would, by itself, have no effect on reinsurance demand. Insurance companies would simply enter the capital markets, raising equity and even debt as needed, in order to put their capital back to original levels. Indeed, given the increase in consumer demand for insurance in the aftermath of a catastrophe, one might expect insurance companies to raise considerable amounts of capital. Thus, one might argue that the increase in reinsurance prices is prima facie evidence that there are capital shortages somewhere in the system.

However, the behavior of prices alone cannot be decisive for whether the supply of reinsurance capital is relatively restricted after events. The combination of prices and quantities, on the other hand, is more decisive. Indeed, the cyclic price patterns turn out to be mirrored by synchronized declines in the "quantity" of reinsurance purchased.

Table 1 provides a kind of event study to demonstrate this. The table shows both price and quantity responses in reinsurance purchased during the year following Hurricane Andrew. (Prices and quantity are measured using the same

9. Paragon produces a catastrophe-price index that, since peaking in late 1994 at 2.47 (and beginning on 1 January 1984 at 1.00), shows the following prices: 2.32 on 1 January 1995; 2.16 on 1 July 1995; 2.14 on 1 January 1996; and 2.06 on 1 July 1996.

10. For a study of demand and supply issues in pricing, see Gron (chap. 1 in this volume).

actuarially expected annual reinsurance benefits that lie behind figs. 1 and 2 above.) It is evident that, in the aftermath of large events like Hurricane Andrew, reinsurance purchases fall. (In practice, this occurs primarily through an increase in insurer retentions.) Indeed, the table shows that the quantity purchased fell by more—and prices rose by more—for those insurers that had greater exposure to the southeastern United States and to hurricanes wherever they occur.

The combination of a postevent increase in price and decrease in quantity cannot be explained by an increase in demand. High demand would be associated with high prices *and* high quantities sold, much as if one were to observe transaction prices and quantities of electric generators sold during a blackout. What is going on in the reinsurance market is different: in the aftermath of events, there is *less* provision of reinsurance capacity even though prices are higher. This can be explained only by a temporary shift backward in the supply of capital.

In some sense, it should also not be surprising that the supply of cat-risk-bearing capital is restricted immediately following an event: after all, large-event losses deplete reinsurers' capital and surplus going forward. For at least a time, however, the high prices and low quantities are consistent with a view that additional capital has trouble flowing into the reinsurance sector.[11]

The final point in this section is that there is a kind of irony in capital market shortages and paucity of reinsurance: much primitive cat risk could be reduced through investments in mitigation, investments that are inexpensive in an actuarial sense. However, many of these investments are not made because they require individuals and corporations, who have scarce capital themselves, to raise (or deplete internal) capital. Thus, capital market shortages are in part responsible for the large and growing risk pool needing insurance and reinsurance. Without capital shortages, reinsurance capacity would be greater, but there would also be fewer risks to reinsure in the first place (see Kleindorfer and Kunreuther, chap. 4 in this volume).

Explanation 2: Prices of Catastrophe Reinsurance Are High because Reinsurers Have Market Power

A number of observers have suggested that the evidence presented above on prices and quantities might be explained by market power rather than by a capital shortage per se. Under this explanation, prices rise, and quantities decline, not because reinsurance capital is impossible or costly to obtain, but because reinsurers have no incentive to increase their capital. By putting less money at risk, reinsurers keep prices high. James M. Stone (see chap. 11 in

11. It is common in the industry for reinsurers to require "paybacks" for event losses and to do so through higher premiums and retentions. Note that, to the extent that it explains the data, there is nothing in this practice to contradict explanation 1. However, an important question remains as to why this kind of contracting prevails and what it tells us about reinsurance markets. For one potential answer, see explanation 5 below.

this volume) has argued that market power among reinsurers may be one reason that, for catastrophe exposures, reinsurance is a much more attractive business than insurance.

It is, of course, very hard to provide evidence that market power among reinsurers has increased secularly over time or cyclically in the aftermath of events. There is a general view that the reinsurance industry has been consolidating over time. There has been a distinct drop, for example, in the number of Lloyd's syndicates since the 1960s and 1970s. There has also been an increase over time in the capital and market share of large reinsurers. But neither of these facts is necessarily associated with increased market power in setting prices or restricting supply. For example, even when there were many more Lloyd's syndicates, catastrophic risk pricing was not typically determined by individual syndicates.

Furthermore, even if consolidation has occurred in the industry, it need not be associated with greater market power. Consolidation may be a natural result of economies of scale in the reinsurance business. Information intensity is one possible source of scale economies. For example, there may be high fixed costs of developing analytic capabilities and systems (see remarks by Stewart C. Myers, chap. 11 in this volume). Once these systems are in place, optimal reinsurer size grows as the required investment in fixed-cost systems increases. Consolidation may also be an efficient industry response to the costs of obtaining reinsurer capital from outside markets. (Size may help here as well.) If, in the extreme case, outside capital was effectively unavailable, then consolidation would follow from reinsurers' desire to diversify exposures and reduce the probability of ruin.

There may also be a kind of interplay between explanations 1 and 2—the insufficient capital and market power stories. Figure 2 above suggests that prices have both increased secularly and undergone cyclic fluctuations associated with cat events. One would be hard-pressed to explain the secular price increase with the insufficient capital story. For example, entry of capital into the Bermudan reinsurers, beginning in 1993 with Mid-Ocean Ltd., suggests that the barriers to capital entry are not overwhelming, at least not over time periods of more than a few years. The insufficient capital story by itself is therefore likely to be better at explaining cyclic fluctuations in prices. However, to the extent that insufficient capital also drives consolidation, it may contribute to market power, thereby indirectly driving prices up on a secular basis.

Explanation 3: Prices of Catastrophe Reinsurance Are High because the Corporate Form for Reinsurance Is Inefficient

Under this explanation, the corporate organizational form of reinsurers is costly. Observers of corporate governance often point out that there are costs associated with discretion given to managers to run a business. In principal, managers could act in ways not in the shareholders' interests. It may be difficult

for shareholders both to identify this behavior and to discipline it. Even if most managers are benevolent, the prospect that a bad manager might use his agency relation against shareholders reduces stock prices and drives up the cost of capital.

This generic corporate-finance argument of "agency costs" has application in a number of arenas. First, it clearly can be applied to insurers and reinsurers. Many of the details of the reinsurance business and the specific contracts are not transparent to arm's-length capital providers. And, given the occasional big-loss nature of reinsurance, it takes many years to evaluate management efficacy and business profitability. In the reinsurance business, bad managers may have an unusually large incentive to take the money and run.

How costly is it to delegate discretion to managers? In the case of some businesses, it is possible get a partial answer. Closed-end funds are one such business. Closed-end funds invest in publicly traded securities and then sell stakes in their portfolio to shareholders, much like mutual funds do. The difference is that mutual funds are "open-ended"; shareholders can sell their shares back to the fund at a price dictated by the net asset value of the portfolio. Closed-end funds do not automatically buy and sell their shares; a shareholder wishing to sell must find another investor. And, like the price of most traded stocks, the price of the closed-end-fund shares must find its own value in the marketplace in accord with supply and demand.

There is a puzzle associated with closed-end-fund shares: their prices are, on average, considerably below their net asset values. This cannot happen with open-ended-fund shares. Closed-end-share discounts average about 10–20 percent and are pervasive across funds. And it is often argued that agency costs account for these discounts. The story is that closed-end funds must pay an average return in excess of what would be required for holding the underlying net assets. The reason is that shareholders can neither observe managers nor easily discipline managers should they turn out to misbehave. The lack of transparency and control means higher capital costs for running a fund, even for ostensibly good managers.

This agency cost of capital may explain why the costs of reinsurance capital—and, by inference, reinsurance prices—are high. This agency argument is buttressed by two regularities. The first is that managers of reinsurers regard their capital costs as "equity-like"—that is, as requiring a return considerably above U.S. Treasury rates. Writing reinsurance at anywhere near actuarially fair premiums is viewed as being against shareholder interest. Yet, given that catastrophe risks are uncorrelated with those of other financial assets, shareholders' required returns on cat risk should, as argued above, be low. Agency costs may be one factor forcing up required returns. The agency-cost explanation may, therefore, help us understand the view in the industry that, for many risks, there is too much capital and prices are too low. Indeed, some public reinsurers (such as Renaissance Re) are, as of this writing, in the process of repurchasing stock because the returns on writing reinsurance are so low.

There is a second regularity behind the view that the corporate form is in-

efficient for the provision of reinsurance. This is that, even without agency costs, there is evidence that shareholders expect reinsurer equity returns to be well above U.S. Treasury rates. Evidence for this comes from the behavior of stock prices of public Bermudan reinsurers, such as Mid-Ocean, Renaissance Re, and Partner Re. These firms hold large property-catastrophe liabilities and generally hold assets in the form of short-term notes and bills. Neither their assets nor their liabilities are correlated with the stock market, yet their share prices comove strongly with the stock market. Specifically, a 10 percent increase in the level of the S&P 500 is associated with an increase in the average value of these firms of about 6.5 percent.[12] All I know about the source of this comovement suggests that it does not emanate from the companies themselves.

If the source of the comovement lies outside the companies, there is an inefficiency. Investors who see a stock with higher systematic risk of moving with the market expect the stock to deliver a higher, more equity-like return. As a result, benevolent managers of reinsurers may be maximizing shareholder value by requiring high hurdle rates for writing reinsurance. This suggests that equity-financed reinsurance may be inefficient even if agency costs are completely unimportant. If equity capital requires an equity-like return and reinsurer assets and liabilities contain no broad equity market risks, then equity is an expensive form of capital, pure and simple. And, if reinsurance is financed in an expensive manner, then reinsurance prices will be high.

Offsetting these arguments are several facts. Roberto Mendoza of J. P. Morgan has argued that Bermudan reinsurers, in particular, have a number of advantages that reduce their costs of equity capital. First, Bermuda's low corporate income tax rate means that reinsurers do not suffer by using equity finance as opposed to debt since there are no interest tax deductions available in the first place. Second, Bermudan reinsurer balance sheets provide an opportunity to achieve tax-free compounding on invested assets (remarks by Roberto Mendoza, chap. 11 in this volume). Both these features tend to lower the cost of equity relative to what it would otherwise be.

Third, rather than an agency "cost," reinsurer managerial discretion may provide an agency "benefit." Smart managers may be able to cherry pick the better risk-writing opportunities, thereby raising share prices.[13] This set of features may imply that the typical corporate form of reinsurers, particularly those in Bermuda, is not so inefficient after all. Indeed, Mendoza (see chap. 11 in this volume) argues compellingly that these advantages make the Bermudan corporate form the most efficient reinsurance delivery mechanism.

Explanation 4: Prices of Catastrophe Reinsurance Are High because Frictional Costs of Reinsurance Are High

This explanation says that prices are high because, as financial instruments, reinsurance contracts are illiquid, have high transactions costs, brokerage, etc.

12. Data on unadjusted stock betas from Bloomberg.
13. Of course, the same argument is often made in defense of closed-end-fund managers.

These sources of friction imply that there are important costs in getting capital and reinsurance contracts together in a repository called a *reinsurer.*

There is abundant evidence that illiquid assets trade at significant discounts. For example, letter stock, as opposed to publicly traded stock, typically trades at discounts of 25 percent; on-the-run bonds trade at significantly higher premiums than less liquid off-the-run bonds; and so on.

However, illiquidity of reinsurance contracts is not enough to drive prices up. In order to raise the cost of capital for reinsurers, reinsurers would themselves need to be financed through illiquid placements. It can be argued that this may have been the case for Lloyd's commitments from names; it is unlikely to be true for publicly traded reinsurers in Europe, the United States, and Bermuda.

Other frictions such as brokerage costs and servicing expenses can legitimately raise the cost of procuring reinsurance. However, these costs are not out of line with other financing charges. For example, in the National Indemnity transaction described above, annual brokerage fees were less than 1 percent of premium and 0.1 percent of limit. If the reinsurance had been issued as a capital market instrument, as had been anticipated by some, these costs would have amounted to about 5 percent of the annual premium. Brokerage/underwriting costs for both traditional and new capital market instruments can be expected over time to be competitive with those on other instruments.

Another kind of frictional inefficiency is the means by which reinsurer portfolios are managed. Often today, and in many more cases in the past, reinsurers manage their portfolios by aggregate limits rather than exposures. For example, a reinsurer might decide that it will risk up to $100 million on Florida, but without specifying the *probability* of Florida losses on contracts written or the covariance of Florida losses with potential losses on North Carolina contracts. Removing such portfolio inefficiencies could have a substantial effect on the cost of risk transfer.

However, the main point here is that the high level of prices seems well above anything that can be explained by brokerage and underwriting costs. Even if brokerage and underwriting expenses had come to a high of 10 percent of premium in the National Indemnity deal, complete elimination of these expenses would have driven down the multiple of premium relative to actuarially expected losses by about 0.6 from 5.3 to 4.7. Brokerage and underwriting expenses cannot explain observed price levels.

Finally, it is hard to argue that inefficient reinsurance portfolio practices keep prices high. The financial technology to improve efficiency exists and can be transferred fairly cheaply. Indeed, the fact that these inefficiencies prevail today seems to be evidence for the lack-of-competition view (explanation 2).

Explanation 5: Prices of Catastrophe Reinsurance Are High because of Moral Hazard and Adverse Selection at the Insurer Level

There is often agreement, implicit or explicit, that reinsurers will charge more in the aftermath of a catastrophe loss. In this sense, property-catastrophe

reinsurance is much like "finite" reinsurance. Finite reinsurance does not so much transfer risk from the cedent as it smooths the risk over time. The insurer uses the reinsurance more as a financing vehicle than as an instrument of risk transfer. During an event, the reinsurer makes funds available, expecting to be paid back later. In its purist form, the arrangement is just event-contingent borrowing.[14] Thus, to the extent that catastrophe reinsurance resembles finite reinsurance, it may be transferring even less risk than might appear on a year-by-year basis. Indeed, a prevalent view in the industry is that it is appropriate to have a "payback" to reinsurers after an event loss and that this drives retention levels up.

While this theme is frequently echoed among practitioners, it further begs the question of why there is so little risk transfer in the first place. Two mechanisms that would explain the use of finite-risk-type contracts as well as high prices and low quantities would be moral hazard and adverse selection.

Moral hazard says that an insurer's behavior might change if it were too easily allowed to transfer risk to reinsurers. Once the risks are transferred, insurers have much less stake in prudent underwriting in the first place. Thus, it may be that the most efficient form of reinsurance is to allow very little risk transfer at all: only by forcing cat risk back on insurers (or by charging a very high price to assume risk) can reinsurers get insurers to expend the resources to monitor and mitigate exposures. A reinsurance intermediary who came along willing to charge a low price and take a substantial quantity of risk from an insurer might find that the insurer misbehaves.

Adverse selection is a related problem. It says that insurers know more about their exposures and underwriting than do reinsurers. Those that are most eager to reinsure at any given price probably have private information that their exposures are worse than average. Similarly, those that are least eager to reinsure have private information that their exposures are better than average. The result is that, at any given price, reinsurers will do business with an adversely selected group of (the worst) insurer risks. Clearly, in the presence of adverse selection, the reinsurer needs to charge more to make up for the degree of adverse selection.[15]

This explanation has some interesting implications (see the discussion below). Unlike explanation 4, it does have the ability to explain high levels of prices. However, it is not clear how it fits all the facts. For example, it is hard to see how the cyclic pattern of prices and quantities would emerge. Why, for example, are reinsurers worried that insurers have a greater motive to forgo monitoring after cat events? Why might the information gap between insurers and reinsurers be greater in the aftermath of an event? Is there a pattern whereby insurers who transfer more risk are less profitable? Much needed is

14. The contingent credit arranged for the Nationwide by J. P. Morgan has many of these features.

15. In some circumstances, higher prices may actually exacerbate the problem, making it impossible for the market to function. For a discussion of the implications of adverse selection on reinsurance contracts, see Cutler and Zeckhauser (chap. 6 in this volume).

further evidence along these lines that moral hazard and adverse selection are operative in the behavior of prices and quantities. Personally, I am skeptical that these explanations can explain prices and quantities, particularly at higher layers. These layers should be relatively immune to moral hazard and adverse-selection considerations because the retentions (deductible amounts) are so high.[16]

Explanation 6: Regulation Prevents Primary Insurers from Pricing Cat Properly

This explanation observes that a number of major high-catastrophic-risk states use regulatory barriers to keep insurance prices down. In some states, lines of business, and specific geographic areas, insurers must underwrite risk at prices well below those that are actuarially and financially profitable. This is perhaps not a surprising state of affairs when the insurance commissioners are publicly elected officials in twelve states, including California and Florida.

Clearly, this situation cannot lead to a high level of prices in the reinsurance market. However, it can explain why there is so little reinsurance purchased even if prices are actuarially fair. The basic reasoning is that, if insurers are unable to earn a profitable return by underwriting risk, they need to cut costs. One way of cutting costs is to avoid purchasing reinsurance.

The mechanism here is analogous to that of rent control. Rent control is intended to make housing more affordable. It does so by reducing the return that owners receive from making improvements in the housing stock. Owners, therefore, make fewer improvements, and the quality of the housing stock falls. This goes on until equilibrium is reached: eventually, the low rents are matched by a similarly low level of housing quality. The equilibrium rental rate—high or low—is none other than a fair one. The old saw, You get what you pay for, holds even in regulated markets.

In response to price controls, insurers likewise have an incentive to provide a product that is of lower quality and therefore cheaper to produce. They have less incentive to purchase reinsurance, even at fair prices, since much of the benefit of that reinsurance accrues to others (policyholders, state-guarantee funds, other insurers, taxpayers, etc.). The result is that state-guarantee funds must bear considerably greater risks that a large catastrophe will become their responsibility or the responsibility of policyholders and taxpayers. In short, everyone suffers if regulation makes it unprofitable for insurers to provide high-quality insurance contracts.

This explanation also fits the cyclic behavior of quantities. After a big event, insurers may feel that their underwriting prices are particularly low. Thus, even with reinsurance offered at a fair price, they will cut back more on reinsurance purchases. The major weakness of this explanation is that it cannot explain

16. For the way in which capital market innovations might help solve these problems (to the extent that they exist), see also the discussion below.

high prices. However, it does explain why insurers may perceive reinsurance prices as high, that is, as being in excess of what they can profitably afford to pay.

Much as with rent control, there is a social policy issue here that will not be dispensed with so easily. What if, for example, the risk of an earthquake occurring along an old fault line in a working-class town suddenly surges? Charging the actuarially justified rate on homeowner's insurance would result in reduced insurance purchases. Housing values would be hit with high homeowner's rates in addition to the hit from the initial earthquake risk. And what of the uninsured? What is the appropriate policy? Should the state or the federal government transfer taxpayer funds to subsidize insurance purchases? Should insurers be forced to bear the cost and spread the burden across all their policyholders by either raising general homeowner's rates or lowering the quality of their product? And, whatever the answer, how does it change if the affected area is not a single town but all of California?

Explanation 7: The Presence of Ex Post Third-Party Financing

Ex post financing of catastrophes occurs when other parties step in to prevent losses from being financed by policyholders. Chief among these entities is, of course, the U.S. government. As is well known, the government has a major role in funding disasters at both the state and the federal levels, through a number of agencies and through both the executive and the legislative branches. During the period 1977–93, the average federal expenditure for disaster assistance was $7.04 billion (in 1993 dollars; see Moss, chap. 8 in this volume). This is far greater than the average annual loss borne by reinsurers on U.S. catastrophe coverage. In some forms of disasters, notably floods, the federal government has effectively eliminated the incentive for the creation of private market insurance contracts. Indeed, before the federal government stepped in to provide disaster relief, private insurers *did* offer flood insurance (see Moss 1996).

The federal government is not the only entity involved in ex post financing of catastrophes. State-guarantee funds and other insurers are often the next line of defense if an insurer is unable to meet its customer obligations. And, if the fund is exhausted, then in many cases solvent insurance companies are to make good on claims against insolvent companies. This creates two types of bad incentives. First, companies have an incentive to shift the burden onto the fund or other insurers before the fund is exhausted. Second, companies who do not act to shift high-layer losses onto the pool are themselves likely to have to pay for others. Well-behaved insurers will wish to avoid doing business in states with guarantee funds and pools. This is another way in which adverse selection can increase the cost of insurance. Overall, the outcome is an incentive for insurers to enter a race to the bottom in customer credit quality (see Bohn and Hall, chap. 9 in this volume). This strengthens the need for regulation and can create a kind of vicious cycle in market and regulatory incentives.

From an economist's perspective, such ex post financing should be viewed as a form of market failure. The federal government cannot credibly commit *not* to fund disasters after the fact: even if it says that it will not provide disaster relief ex ante, the political incentives to do so ex post are overwhelming. Given that this is the case, no one would have the incentive to buy a private-insurance contract at an actuarially fair price or greater since the government effectively subsidizes losses through these programs. Of course, taxpayers will pay for subsidized losses by some means. The government is unlikely to administer a disaster program and monitor disaster payments as well as a dedicated insurer would, so the size of the loss (net of processing costs) paid by taxpayers is likely to be that much greater. Also, there is no mechanism to discipline risk-taking incentives: population growth in high-flood-risk zones is not moderated by charging risk takers for the expected losses that they impose on the system.

How does ex post financing affect the price and quantity of reinsurance? Clearly, insurers have less incentive to provide insurance in the presence of ex post financing. One way of doing this is by not underwriting risk in the first place. A second way is to shift the actuarial costs of the risks onto others. Since insurers must pay for reinsurance but may obtain ex post financing at lower (even zero) costs, they have an incentive to substitute away from reinsurance.

As with explanation 6, ex post financing cannot explain why prices might be high. It can, however, explain why insurers perceive reinsurance prices as high. It can also explain low quantities of high-layer reinsurance and the cyclic downturns in quantities after major events.

Explanation 8: Behavioral Factors

A commonly cited reason for the low quantity of high-layer reinsurance is that the *perceived* likelihood that reinsurance will pay is too low to matter. This issue about perception is ubiquitous in insurance markets.

For economists who use a utility-based approach to understand behavior, insurance against severe but low-probability events is very valuable to consumers. Utility-type approaches argue that outcomes that lose twice as much are perceived by people as more than twice as bad. Yet, in contrast, people often do not insure against low-probability, severe outcome events. They often underpurchase insurance. They often do not take mitigation seriously, and, when they do, they require too high a return on mitigation expenditures (see Kleindorfer and Kunreuther, chap. 4 in this volume).

There are many potential reasons for this behavior. One is that people discount too heavily events that they cannot readily perceive. Famous studies from the 1970s (e.g., Tamerin and Resnik 1972) show that the rate of smoking is higher among the general populace than among general practitioners, higher among general practitioners than among internists, and higher among internists than among specialists who work directly with lung cancer patients. Even when the consequences and probabilities of bad outcomes are well known,

the repeated hammering home of bad outcomes affects behavior (Diamond, comment on chap. 2 in this volume).

A second behavioral effect is that individuals often seem "ambiguity" averse. A lack of clarity about the risks and events being insured may lead insurers and reinsurers to set premiums high (see Kunreuther, Hogarth, and Meszaros 1993). Behaviorally, people distinguish between risk and uncertainty. With risk, the probabilities of different outcomes can be determined. Examples would be lotteries or card games. With uncertainty, however, the probabilities cannot be determined. What is the likelihood of an earthquake in Boston? How frequently is a well-built house on the Florida coast destroyed by wind? Uncertainty is inherently more ambiguous, and surveys suggest that individuals charge more to bear it.

A related behavioral argument is that big events do not generate enough "job risk" for people in charge of buying insurance and reinsurance. Studies of corporate insurance purchases, for example, tend to show that mid-layer risks are often insured more frequently than high-layer risks. The argument is that managers are off the hook if the event is large enough since many others will be in the same boat. For smaller events, insurance is easily available and purchased by others, which reinforces the desire for a manager to purchase (re)insurance. It is worth noting that this argument is another form of agency cost—"job risk" would not be an issue if people were buying insurance on their own behalf.

As under explanations 6 and 7, pricing may be fair under the behavioral hypothesis, but the quantity of risk transfer is nevertheless low.

Moving Ahead: Changing the Distribution of Risk through Capital Markets, Deregulation, and Alternative Risk Transfer

Many observers, practitioners, and academics have argued that bringing cat exposures directly to the capital market can help reduce reinsurance prices and increase risk transfer. Mechanisms include cat-linked bonds, swaps, exchange-traded options and futures, cat-linked issues of equity, etc. (see, e.g., Cummins, Lewis, and Phillips, chap. 3 in this volume).

Clearly, the degree of success that the capital markets can hope to bring depends on one's assessment of the explanations outlined above. If the problem is that catastrophe-risk-taking capital is insufficient (explanation 1), then the capital markets clearly represent a potential solution. Indeed, the $50–$100 billion events discussed earlier are equal in size to a normal day's fluctuation in the value of U.S. equities. With U.S. financial assets totaling over $12 trillion, a large catastrophic event represents only about fifty basis points of wealth.

Similarly, if the problem is that the corporate form of today's reinsurers is inefficient (explanation 3), capital market devices would seem to help. Cat bonds specifically collateralized in a special purpose trust to fund insurers'

higher-layer cat risks would not be subject to the kinds of agency costs experienced by firms. Moreover, if the equity of these firms is costly because of its tendency to move up and down with the market, then these costs could also be eliminated by embedding the risk in a cat bond, which would be treated more as debt.

Certainly, these investments would at first need to provide an average return in excess of U.S. Treasury bills. Indeed, cat bonds were originally envisioned for the CEA reinsurance layer written by Berkshire Hathaway and were to be offered on terms not so different from the reinsurance. If these prices are to decline, it is clear that considerable infrastructure must first be laid. Investor education about cat risks, for example, is an important externality and will take time to build.

Another important piece of infrastructure is a means for standardizing risk. Simple securitization of existing reinsurance contracts is unlikely to lower costs or increase capacity. Reinsurance contracts have tailor-made features and cover company-specific exposures; they are, therefore, informationally intensive as investments. It makes little sense for individual investors, or their institutional investment agents, to analyze these instruments. Existing reinsurance conserves on analysis by concentrating the exposures in a few places. Clearly, if it is to be economical to spread cat risk more widely, more standardization will be required.

Catastrophe indexes are one way to accomplish this. Indexes help avoid the redundant analysis of distinct risks. They also help promote liquidity, which further lowers the cost of risk transfer. Furthermore, to the extent that moral hazard and adverse selection (explanation 5) are sources of high prices and low quantities, indexes can help. If insurers transfer risks that are linked to industrywide losses, they can reduce the problems of moral hazard and adverse selection faced by investors. Individual insurers may have control over their own losses and know more about those losses than reinsurers. However, they do not have control over, nor do they know more about, index outcomes. Thus, indexes can make risk transfer more efficient, regardless of whether it occurs through capital market devices or traditional reinsurers. Indeed, index-linked cat reinsurance is already gaining popularity as a way of reducing reinsurer capital costs.

Of course, the standardization of an index is, all else equal, a disadvantage from the perspective of the (re)insurance buyer. An insurer would like to protect itself against *its* losses, not insurance-industry losses. Thus, a critical issue in index design is that the index be flexible enough to keep down the "basis" between insurer-specific and index risk. An effective index must provide good hedging tools for cat-risk cedents.

Indeed, my own view is that existing indexes have not caught because they are poorly correlated with individual insurer losses, given a large event. Existing indexes aggregate industry losses at the statewide level. Unfortunately, however, insurer exposure as a percentage of total industry exposure varies

considerably within a state. The right hedge ratio, therefore, varies considerably within the state. To see this, suppose that a company hedges on the basis of its 5 percent statewide market share and that a storm destroys a small portion of the state where the insurer's market share happens to be 10 percent of the market. Only half the insurer's losses will be covered by the index. In short, statewide blocks are too large to yield low-basis risk. To serve as good insurer hedges, indexes will need to report industrywide losses for smaller geographic blocks (i.e., zip codes).[17]

Much of this is now being tested as a new catastrophe exchange located in Bermuda has recently opened. The Bermuda Commodities Exchange (BCE), owned by AIG, Guy Carpenter, and Chase Manhattan, and involving the Chicago Board of Trade, will trade contracts based on a U.S. homeowner's catastrophe index developed by Guy Carpenter. The index aggregates losses at the zip-code level and can, therefore, match the exposure of certain insurer portfolios more precisely than statewide indexes can.

Clearly, however, whether capital market devices can work will depend on which of the eight explanations outlined above for the paucity of risk transfer are telling. For example, if the problem is purely reinsurer market power, then innovations in financing will lower prices and increase quantities only if new entrants come along and make the market more competitive. On the other hand, to the extent that market power is created by high reinsurer costs of capital, capital market solutions could help reduce the adverse effects of market power.

Lowering the costs of risk transfer may provide savings, but it cannot directly solve the problems that result from state regulation and insurance pricing (explanations 6 and 7). However, transparent pricing of catastrophe risks in the reinsurance market may have important benefits for the efficiency of regulation. The market pricing of electricity is forcing the rationalization of utilities across the United States. This process will result, not only in more efficient plants and equipment, but also in more rational pricing by utilities and their public commissions. Customers will benefit by having a transparent and observable market energy price to which to tie ratepayer contracts and service. By analogy, reinsurer and insurer financing costs can be useful benchmarks for a regulatory review of underwriting prices. However, pricing is only one of many regulatory hurdles that may prevent efficient distribution of catastrophe risk.[18]

Clearly, government regulation can facilitate or impede risk transfer outside

17. For an analysis of how hedge performance is affected by geographic aggregation, see Major (chap. 10 in this volume).

18. Another example of costly regulation is that financial instruments linked to catastrophe losses can in some cases be considered insurance contracts by state insurance commissioners. Because only licensed insurers are allowed to write such contracts, financial instruments that transfer premiums to investors in return for catastrophic risk bearing must seek exemptions and approval from commissioners.

traditional reinsurance channels. Regulation can also mandate reporting of loss and exposure information to authorities, thereby permitting easy aggregation. Much as with Fannie Mae, the government can pursue "market-enhancing" policies designed to jump-start broader market exchange of these risks.

Going forward, it is most likely that traditional reinsurance contracts will continue as the preferred risk-transfer vehicle even if capital market and other alternative-risk-transfer solutions take off. Insurers that are small and/or have less well-diversified exposures are likely to continue placing their risks with reinsurers. Indeed, it may well be that reinsurers, not insurers, will be the direct beneficiaries of capital market products. These products will simply allow reinsurers to place their risks with investors in many forms other than those of standard equity. The almost inevitable result is that the reinsurer cost of capital will decline and specialized capacity increase. As a result, more insured assets will be insurable than ever before. This will make risk sharing in society better, with better risk sharing being the fundamental goal of an insurance system.

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