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The CAS Committee on Valuation, Finance, and Investments (VFIC) presents for discussion six papers prepared in response to the 2010 call for discussion papers on valuation topics related to the 2008 financial crisis and its implications for the property-casualty industry. This *E-Forum* also includes one additional paper.

Some of the VFIC discussion papers were discussed by the authors at the 2010 CAS Annual Meeting, on November 7-10, 2010, in Washington, DC.

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A Conceptual Proposal to Use Appraisal Value as a Supplementary Basis for Financial Valuation

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Abstract: This paper argues that no single valuation basis is completely reliable: neither market price nor other alternatives can accurately measure value. Therefore, this paper proposes that a preferable solution is to simultaneously record two bases of valuation: market price and appraisal value. Thus by expanding the dimensionality of financial reporting, one can provide a broader, richer, and more accurate measurement of value.

Keywords: Valuation; market price; appraisal value; financial reporting.

1. INTRODUCTION

One of the central questions of finance is how one should measure, quantify, and record in financial statements the uncertain values of assets and liabilities. This paper describes a conceptual proposal that addresses some of the issues that arise in this debate.

2. BACKGROUND

One of the overarching trends during recent decades has been the ascendancy of the financial economics or "market price" method for valuation. According to this approach, the only true value of an asset or liability is the value that arises in the open market when buyers and sellers agree on price. As a result, there has been a significant shift away from previous methods of valuation towards the use of market price. The financial crisis of 2008, however, has highlighted the need to reevaluate this framework.

We first explore the conceptual bases for using market price and examine their implications; then we propose an alternative valuation methodology to complement market price.

3. MARKET PRICE

3.1 Market Price Valuation Rooted in the Efficient Markets Hypothesis

The market price approach rests partly on the foundation of the "efficient markets hypothesis," which states that all known information has been incorporated or "priced into" the market price; thus, the market becomes some form of supremely intelligent force that always reflects the "true

price" at any moment. According to this theory, one should always value assets and liabilities at market price; whether one is seeking to actually sell an asset in the market or not is irrelevant, because the cogency of the argument derives from the inherent correctness and exclusive accuracy of the market price. Thus according to this theory, market price would be not only a *valid* basis for valuation but also an *exclusive* basis for valuation.

Although the efficient markets hypothesis has a noble pedigree, reality has stubbornly refused to conform to its predictions. One known problem is that market prices show an inordinate amount of volatility relative to new information. If the market price truly reflected the inherently correct value at any single point in time, it would be unlikely that the market price would greatly change from moment to moment in the absence of new real information; yet such pronounced volatility is a known trait of market prices. Another known problem is the formation of bubbles, manias, and panics. All of these phenomena are temporary situations in which the market price distorts information and unhinges itself from the underlying economic value, with painful consequences when the market price corrects.

Therefore, in this paper, we shall reject the idea that the market price at every moment in time reflects some form of true or inherently correct price. Therefore, this conclusion suggests that market price cannot make a claim on being an *exclusive* basis for valuation.

3.2 Market Price Valuation Rooted in No Arbitrage Pricing

The use of market price, however, does not derive solely from the efficient markets hypothesis. In fact, a very different conceptual framework also demands the use of market price: "no arbitrage pricing." No arbitrage pricing, however, does not necessarily ascribe perfect knowledge to the market; the market price is not an inherently correct or normative price. Rather, no arbitrage pricing requires that one use market price simply because market price reflects reality: this is the price at which one can (and should and must) sell or "realize the value of" an asset. No arbitrage pricing simply acknowledges that the dollar amount that one can actually obtain is rooted in the current market price; not only is market price a *valid* basis for valuation, it ought to be the *exclusive* basis for valuation.

According to this logic, however, the cogency of this argument seems to derive from the presupposition that one seeks to immediately sell or realize the value of something; but what if one were able and willing to hold an asset and not sell at the current market price? Would this behavior blunt the logic and dilute the applicability of using market price as the exclusive basis for valuation?

Or, even further, would market price, rooted in no arbitrage pricing theory, be disqualified as a basis for valuation?

This situation in which a firm does not intend to sell its assets is highly relevant because the premise of GAAP accounting is that the firm is a "going concern" and not in liquidation. Indeed, the apparent disconnect between the premise of "no arbitrage market pricing" and "going concern" is so striking that one might be tempted to argue that market pricing is inconsistent with the premise of going concern This argument, however, is specious. Market price, rooted in no arbitrage pricing is, in fact, consistent with going concern via the concept of *imputation*.

3.2.1 Imputation

To impute value to an item is to assign value to it, often by comparing the item with something else that is similar with known value. The more precise the comparison, the more compelling the imputation of value will be.

The underlying premise of market price valuation via the theory of no arbitrage pricing derives from *imputation*. The idea is that if Firm A holds an asset that is exactly similar to Firm B, and Firm B has just sold the asset for Market Price $X, then it is reasonable to assign this market price to the asset that Firm A is holding.

For example, if Firm A holds equity shares in IBM, and Firm B has recently sold shares of IBM for a certain market price, then it would be reasonable to note that (1) Firm A's shares of IBM are essentially identical to Firm B's shares, so the two are quite comparable; and (2) therefore we can take the value that Firm B received for its shares of IBM and *impute* that value to the shares that Firm A holds, *even though Firm A is a going concern and has no intention of selling its shares.*

Therefore, when one advocates for using market price as a basis of valuation, this basis derives from the conceptual framework of imputation. One is not saying that the firm whose assets and liabilities are being valued somehow intends to actually sell them; rather, one is saying that a firm that specifically does not intend to sell its assets (going concern) can nevertheless *assign* value to its assets and liabilities based on market price, rooted in the intersection of the concepts of (1) no arbitrage pricing and (2) imputation.[1]

[1] One often hears the argument that a firm that intends to hold its assets and liabilities "to maturity" should be exempted from market price valuation. However, the concept of "imputation" shows that this argument is flawed; market price is indeed valid even for an item that is "held-to-maturity."

Therefore, the presumption of going concern does not disqualify using market price as a basis of valuation; market price, via no arbitrage pricing, remains a *valid* basis of valuation. But because the firm does not intend to actually sell its assets and liabilities, one cannot say that market price, via no arbitrage pricing, ought to be the *exclusive* basis of valuation.

3.3 Traits of Market Price

As we have noted, in some situations using market price is compelling, whereas in other situations using market price seems less compelling. This duality arises because the market price has traits that make it very useful but simultaneously has characteristics that make it subject to biases and distortions.

One trait of market price is that it usually arises from the interactions of many buyers and sellers. This trait can be positive, because information is often diffuse; price thus reflects the aggregation of information from many sources. This same trait, however, can also be a weakness; the large number of participants in the market may allow non-expert actors to influence the market price, which can lead to positive and negative bubbles.

A second trait of market price is that it reflects the immediate behavior of participants in the market but is not necessarily stable or robust across time. For example, the market price may reflect the behavior of actors known as distressed sellers, who are forced by external circumstances to sell, resulting in an unusually low current market price. But once the force of distressed selling ebbs from the market, the market price may rebound significantly; thus the current market price may reflect a distorted view of likely future prices. The current price, reflecting the exigencies of the moment, may serve as a poor guide to likely prices in the very near future.

4. APPRAISAL VALUE

4.1 Appraisal Value as an Alternative to Market Price

The known weaknesses of market price demonstrate why market price is not sufficient to serve as the sole basis of valuation. Moreover, the specific drawbacks of market price point towards a potential remedy: to supplement the valuation of any asset or liability by looking not only at the market price but also at the "appraisal value." What is the appraisal value? We define appraisal value as the value, as estimated by independent experts, of the sale price from a knowledgeable, non-distressed seller to a knowledgeable, non-euphoric buyer. We underscore the importance of

"independent" and "experts."

4.2 Traits of Appraisal Value

Appraisal value is the polar opposite of market price. Whereas market price derives from the interactions of many diffuse players, appraisal value derives from only a handful of individuals. Whereas market price might reflect the views of many non-experts who are not fully informed of all the underlying details of an asset or liability, appraisal value must be calculated only by experts with sufficient access to data and sufficient time to painstakingly inspect all the underlying details of the situation. Whereas market price reflects distressed sales and all other exigencies of the moment, appraisal value seeks to understand price based on a "stable environment" free of dislocation from positive or negative bubbles.

Based on this discussion, we conclude that many traditional valuation methods share a common conceptual basis rooted in appraisal value. Some examples are the valuation of real estate; appraisals of fine art, wine, antiques, and collectibles; independent research analysts' estimates of equity prices; and actuarial valuations of insurance liabilities.

Because several traits of appraisal value are the inverse of market value, it is logical that the situations in which market value performs poorly are exactly the situations in which appraisal value performs well, and vice versa. Some situations that would likely accentuate the utility of an appraisal value methodology would be:

1. Valuations during periods of market euphoria (bubbles) and periods of market depression (panics).
2. Valuations of complex assets and liabilities whose workings are opaque to the market.
3. Valuations of opaque conglomerate firms with many subsidiaries.

5. PROPOSAL

Market price is an important indicator for valuation purposes, but it is not perfect; there are times when market value provides an inaccurate and distorted view of value. Appraisal value also is an important and legitimate approach to valuation, but it too is imperfect; there are times when appraisal value provides an inaccurate picture of value. Moreover, the availability of two different valuation bases could create an irresistible temptation to adopt one basis during good times and then

to switch the valuation method when conditions deteriorate.

We therefore propose that financial valuation should always present both bases for valuation: the market price and the appraisal value.

Exhibit 1: Sample Conceptual Balance Sheet

	Market Price	Appraisal Value		Market Price	Appraisal Value
Assets			Liabilities Equity		

This proposal implies that there would be no single number for "the value" of anything; rather, all assets and liabilities have various facets of value and therefore manifest at all times both a market price and an appraisal value. Of course, for many assets and liabilities during many time periods, the market price and the appraisal value ought to be similar. But the gap between market price and appraisal value could be significant and telling during certain time periods for certain types of assets and liabilities. Recording both the market price and the appraisal value would facilitate:

1. Investigating the absolute magnitude of the difference between market price and appraisal value.
2. Analyzing how the spread between market price and appraisal value expands or contracts over time.
3. Measuring how the spread between market price and appraisal value compares and contrasts across various types of assets and liabilities.

When consistently recording both market price and appraisal value, one needs to make only a single yet critical choice: which basis of valuation to embrace for decision-making purposes. This choice could depend on several factors, ranging from the condition of the market, to the type of

asset, to the job description of the particular person making the decision. Some possible choices are:

1. Regulators might embrace market value until there is a "very large" gap between market price and appraisal value; market price significantly exceeding appraisal could signal a higher probability of a bubble, and appraisal value significantly exceeding market price could signal a higher probability of a distressed market. This framework could, for example, assist regulators to achieve the goal of countercyclical capital requirements.
2. Market participants such as investors and traders might focus exclusively on market price, whereas regulators might use appraisal value when deciding upon regulatory action.
3. Regulators might choose to embrace market price for certain assets such as equities while simultaneously choosing appraisal value for other more opaque, complex, and illiquid assets and liabilities.

While there are numerous possible approaches, they would all benefit from the information supplied by a multifaceted valuation framework that records both market price and appraisal value.

5.1 Application to the 2008 Financial Crisis

5.1.1 Regulatory Forbearance

The financial crisis of 2008 exposed some of the weaknesses of mark-to-market valuation, especially with respect to triggering regulatory intervention; it also showed the possible utility of basing regulatory action upon valuations derived from appraisal value rather than market price. One aspect of this crisis occurred when distressed selling drove down the market price; valuations based on market price then transmitted these asset price declines to other non-selling institutions that held similar assets; this deterioration in recorded asset valuations reduced the recorded value of equity, which then triggered the regulatory response that these institutions had insufficient equity capital, leading to further distressed selling of assets, leading to further depressing the market price of assets, thus completing an endless loop. Had regulators evaluated the capital adequacy of firms by focusing to a greater degree on appraisal value, firms would not have been required to sell assets into a distressed market. In fact, this is (eventually) what regulators implicitly did: the Federal Reserve decided that capital adequacy would be calculated (albeit in a controlled, uniformly applied "stress test") based on the appraisal value of complex, opaque assets and liabilities. Had the regulatory apparatus pre-committed before the crisis to using appraisal value as its basis of valuation of assets, liabilities, and capital adequacy, some aspects of the panic could have been averted.

We also note that different groups could simultaneously take different approaches to valuation: market traders could use their own views of the value of the firm, while regulators could give less weight to distressed market prices and more weight to appraisal value when deciding if regulatory intervention was needed. Therefore presenting both market price and appraisal value would allow valuation to serve multiple audiences, without the informational needs of one group interfering with the informational needs of another.

5.1.2 Mark-to-Model

One of the features of the financial crisis was the phenomenon of "mark-to-model." In this situation, various assets had previously been valued based upon market information; when markets imploded and there were no market clearing transactions, firms resorted to valuation models to place a value on these assets. Mark-to-model was the flashpoint for quite a bit of controversy: is it an appropriate valuation method or not?

The proposal to simultaneously display both appraisal value and also market price would have significantly reduced two of the problematic aspects of mark-to-model:

1. First, one of the serious problems of mark-to-model is the inherent conflating of market price and appraisal value; having previously committed to using market price, switching to appraisal value is a complete paradigm shift in the underlying valuation framework. To have these values commingled in one single column of valuation numbers is inconsistent, confusing, and confidence-destroying. In contrast, had valuation always been presented on both bases of appraisal value and market price, this problem would have been ameliorated. Information in the mark-to-model appraisal value would not have been presented as a form of market price but rather would remain in its own separate column, clearly marked as appraisal value, not market price.
2. Second, switching from mark-to-market to mark-to-model makes a sloppy intellectual assertion: that when there previously had been a market price that has now evaporated, this is not informationally significant! True, there is no market now; had there never been a market for this asset or liability, then the nonexistence now would be inconsequential. Yet when a market for an asset had previously existed and now the market has seized up so that a market price no longer exists, this is very relevant because it signifies the likely deterioration in the value of the asset. In such a situation, to not disclose this massive dislocation of market prices is to ignore significant information. In contrast, had valuation

always been presented on both bases of appraisal value and market price, this problem would have been lessened. Mark-to-model would not have supplanted and obscured market price information but rather would have been presented alongside it, and significantly depressed market price information could have been communicated unfettered to investors. Then both investors and regulators could evaluate the relevant quality, reliability, meaning, and importance of the two valuation measures. Instead, we experienced months and years of firms recording values that no one had faith in ("mark-to-myth"), destroying confidence and paralyzing market participants.

Exhibit 2: Current Framework vs. Proposed Framework

Current Framework: Normal Environment

	Value		Value
Assets	110 (mark-to-market)	Liabilities	90 (mark-to-market)
		Equity	20 (mark-to-market)

Current Framework: Crisis Environment

	Value		Value
Assets	95 (mark-to-model)	Liabilities	90 (mark-to-model)
		Equity	5 (mark-to-model)

Proposed Framework: Normal Environment

	Market Price	Appraisal Value		Market Price	Appraisal Value
Assets	110	100	Liabilities	90	90
			Equity	20	10

Proposed Framework: Crisis Environment

	Market Price	Appraisal Value		Market Price	Appraisal Value
Assets	80	95	Liabilities	90	90
			Equity	-10	5

6. CHALLENGES TO IMPLEMENTATION; DANGERS

The goal of this paper is to introduce the conceptual proposal that valuation should display more than one value: an appraisal value and a market price. Yet one cannot ignore some practical challenges that could arise when implementing such a proposal. Some challenges to implementation could include:

1. Expertise and Independence: we defined appraisal value as a value determined by "experts" who are "independent." In order to qualify as independent, the appraisers ought to not be employees of the firm whose assets and liabilities are being appraised; they would need to be employees of a third-party valuation firm. Who should qualify as an expert? Does the firm being appraised retain the right to hire and choose the particular appraisal firm? If so, does the hiring process itself subvert independence? While all of these questions are germane, they are not qualitatively more difficult than similar questions that have arisen in other similar contexts (e.g., hiring public auditing firms, etc.).
2. The "Prisoners' Dilemma," Disagreement, and Coordination: should all expert appraisers be allowed to use their own unique methodology for determining the appraisal value? Would such a situation lead to a downward spiral in which appraisers compete to win business by promising the most favorable appraisal? To what extent should regulators serve a "coordinating" function, in the sense that they impose some constraints on some valuation choices and thus save the individual appraisers from destructive competition? For example, it might be undesirable to have a particular company's commercial real estate assets appraised by a valuation firm using a 10% default rate assumption while another company's assets are appraised by a different valuation firm using a 20% default rate assumption. Like the Fed's "stress tests," there might be sound logic for coordinating certain uniform assumptions across all firms approved for performing appraisals.
3. Disclosure of Methodology: because appraisal value is so highly dependent upon the valuation assumptions of the appraiser, the firm reporting its assets and liabilities would have to meticulously document and describe the underlying appraisal methodology in order to satisfy its investors. How would this be done? In what level of detail? While these are important questions, they are not radically different than the current issues that arise when a firm uses mark-to-model methodology and discloses the underlying model assumptions.

4. The Illusion of Adjacent Expertise: in the financial crisis, we observed problems with rating agency evaluation of structured financial products such as CDOs. These financial instruments, in fact, were materially different from the vanilla securities that the rating agencies had a long, successful track record of evaluating. The expertise the ratings agencies had was in evaluating corporate debt, which was an adjacent market to structured products such as CDOs. The ratings agencies' expertise in one market, it turned out, did not mean they were experts in an adjacent market, yet the adjacent expertise served to facilitate this illusion.
5. Appraisal Value is No Panacea: if firms were to record both the market price and also the appraisal value, this would help reduce the frequency and severity of financial crises, but it would certainly not reduce them to zero. After all, appraisers can also fall victim to positive and negative euphoria and thus fail to produce reasonably accurate estimates.

The proposal is not riskless; it also introduces new dangers. One significant danger is that appraisal value could be used to subvert the discipline that mark-to-market valuation imposes; appraisers might use unrealistically rosy assumptions to prop up certain institutions favored by politicians, regulators, or particular interest groups.

7. APPLICATION TO PROPERTY-CASUALTY INSURANCE

The discussion thus far of market price and appraisal value has related generally to the financial industry. What ramifications does it have when applied specifically to the property-casualty insurance industry?

7.1 Loss Reserves: Appraisal Value

One of the most important financial items to quantify in the property-casualty insurance industry is the liability for loss reserves. Historically, this liability has not been estimated using market price; the lack of an actively traded market of insurance liabilities has been a critical impediment to using market price. Rather, loss reserves have been estimated via an actuarial appraisal of the liability value. Does current practice indicate that actuarial appraisals are in line with appropriate standards for appraisal valuation? Our discussion defines appraisal value as a sale price between a knowledgeable, non-euphoric buyer and seller. Almost certainly, knowledgeable buyers and sellers require a sale price to include (1) the time value of money and (2) a margin for risk; therefore, because actuarial

appraisals and current USA accounting methods for loss reserves do not provide for these two elements, it would seem that current practice does not comport well with the framework of appraisal value as defined in this paper.

7.2 Loss Reserves: Market Price

In recent years, the Solvency II required capital framework has promoted the use of market of values for assets, liabilities, and equity capital. Under this rule, the loss reserves' contribution to the firm's risk and capital corresponds to the one year downside move in the market value of the loss reserves. Naturally this framework raises the question of how to measure the "one-year downside move in the market value of loss reserves" when there is generally no active market for loss reserves. The lack of clearly observable market prices for loss reserves has created a need for actuarial models of the "market price of loss reserves." How should we evaluate the appropriateness of these actuarial models in light of the proposal to record valuation on both an "appraisal value" basis as well as a "market price" basis? Before addressing this question, we ought to inspect the interrelated issue of time horizon. Given that loss reserves correspond to liabilities that will be paid over multiple future years, on what basis does Solvency II allow downside risk and capital to be defined on a one-year basis?

7.2.1 Excursus on Solvency II "One Year Horizon" for Long Tail Loss Reserves

At first blush, one might object to the apparent mismatch between the multi-year time frame of loss reserves liabilities and the one-year time frame for required capital. In fact, one might strongly prefer to calibrate required capital based on the multi-year downside move in loss reserve liabilities across the entire multi-year period needed to pay all the claims and extinguish the risk. How then can one justify using a one-year capital time when liabilities and risk continue for multiple future periods?

The only logic that can justify the one-year horizon is as follows. At the beginning of year one, the firm holds sufficient capital to withstand even a significant one-year downside move in its loss reserves liabilities; at the end of the year, the firm can sell its loss reserves in the open market or, equivalently, raise equity capital in the open market. This logic, while sound, shows that the "mismatch" between multi-year loss reserves and single year required capital is justifiable only under the assumption that after one year the firm can actually sell liabilities in a real-world transaction or attract an infusion of equity capital in a real-world transaction. Therefore, any model of the one-year move in the market value of reserves ought to measure the one year move in the actual market price

required to sell liabilities or attract an equity capital infusion. Yet as discussed earlier, we know that actual prices in the real-world market are subject to animal spirits that can lead to distortions such as overreactions and panic, as well as extreme suspicion rooted in asymmetric information. For actively traded financial instruments, such behaviors of the market can be somewhat quantified by measuring statistical volatility of observed market prices. For non-actively traded instruments such as insurance liabilities, such behavior is more difficult to measure. Any model that does not incorporate such behavior of real world market prices will understate volatility.

7.2.2 Evaluating Current Actuarial Models of Loss Reserve Risk for Solvency II

Many actuarial models of loss reserve risk are rooted in measuring the statistical behavior of the underlying claim payments; they do not measure the statistical variability of a market measure. Such a perspective would be wholly reasonable within a framework that calibrated required capital based on a multi-year or "runoff" view that matched the time horizon of the liabilities. Yet for a single year view of capital, one must estimate the one-year variability of the market price, including all the passions, overreactions, herd mentality, and distortions that the market price exhibits. This means that current actuarial models of reserve risk are more accurately classified as models of the variability of "appraisal value"; yet what the actuarial community requires for calibrating required capital for Solvency II is a model of the variability of the "market price" of loss reserves. Such a model of market price would likely calculate a much larger one-year variability than current appraisal value models, suggesting a risk that current Solvency II required capital for loss reserves is too low.

Exhibit 3: Categories of Actuarial Models of Loss Reserve Risk

Category #	Category Name	Time Horizon	Assumes that After One Year of Downside…	Measures Variability of
1	Appraisal Value	Multi-year runoff	The firm can rely on preexisting held capital to weather further downside risk	How the market price *ought to* behave
2	Market Price	One year	The firm can sell its liabilities or can raise equity capital	How the market price *actually* (mis)behaves

8. CONCLUSION

In this paper we argue that there is no such thing as "the value" of anything; rather, there are various metrics that describe different perspectives of value. We propose that one should always measure and record two key perspectives of valuation: market price and appraisal value. Both market price and appraisal value are imperfect measures of value with known weaknesses, but each has significant strengths that complement each other when used in concert.

One essential requirement of appraisal value is that it should be calculated by "experts" who have the knowledge, time, and access to data in order to delve into the underlying details of the valuation. A second key requirement is that the appraisal value should be calculated by experts who are "independent" of all parties who have vested interests in the appraisal.

Consistently disclosing the complementary perspectives of market price and appraisal value will provide a broader perspective on valuation and will thereby help firms, investors, regulators, and

taxpayers all achieve better outcomes.

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Banking on Robbery: The Role of Fraud in the Financial Crisis

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Abstract: In his book, *The Best Way to Rob a Bank is to Own One*, William Black describes in detail the complex collusion between bankers, regulators, and legislators that brought about the Savings and Loan crisis of the 1980s and early 1990s. As part of the scheme, leverage was used to purchase bankrupt companies that became the basis for a Ponzi-like speculative bubble that ultimately collapsed. Deceptive accounting rules were used to hide the true state of the banks. Litigation and lobbyists were used to delay and frustrate timely enforcement, adding significantly to the taxpayer's bill. Since the bursting of the S&L bubble, a number of additional financial bubbles and debacles have occurred, including Enron, the Internet bubble, the subprime bubble, and the Madoff Ponzi scheme. The details of the S&L crisis—civil and criminal trials and federal agency investigations—have been well-documented and will serve as a model for later crises. This paper will describe how fraud and corruption played significant roles in these financial crises, including the current crisis that began in 2007 and is still unfolding.

Motivation. Though "moral hazard" and "the principal agent problem" are frequently cited when discussing the causes of the financial crisis, relatively little research has focused on the role of fraud. This paper highlights the role of fraud and corruption in the financial crisis.

Method. We review the fraud literature with respect to past financial crises, and highlight commonalities between some of the well-documented financial frauds of the past and the current global financial crisis. We also support our arguments with some statistics from the current crisis that predicted the bubble before it burst.

Results. The evidence indicates that a well-established and well-known permissive attitude towards fraud created a global systemic risk of such significance that a financial crisis of major proportions was all but inevitable.

Conclusions. Reinstitution of previously abandoned regulations that protected the banking system from risk (i.e., Glass-Steagall Act) and a new commitment to SEC enforcement of already existing anti-fraud laws are greatly needed. If fraud is not pursued and prosecuted, future financial crises where fraud is a significant factor are likely to occur.

Keywords. Financial crisis, fraud, systemic risk.

1. INTRODUCTION

In his book, *The Best Way to Rob a Bank is to Own One,* William Black describes in detail the complex network of collusion between bankers, regulators, and legislators that brought about the Savings and Loan Crisis of the 1980s. The author coins the word "control fraud" to denote a "wave of frauds led by men who control large corporations."[1] Control frauds are of special concern because the perpetrators of fraud gain control of the corporation (thereby subverting internal management mechanism that could have prevented the disaster), as well as its lawyers, accountants, lobbyists and through them legislators and regulators. As a lawyer working for the Federal Home Loan Bank Board under Ronald Reagan, Black has an

[1] Black 2005, page XIII.

insider's knowledge of many details not generally known. The participants and enablers included Charles Keating of Lincoln Savings, junk bond king Michael Milken, highly placed politicians such as former speaker Jim Wright (who was forced to resign in disgrace) as well as accounting conventions whose fraud friendly rules helped hide the true extent of the collapse for a long period. As bad banks were allowed to buy other banks, using phantom capital, a Ponzi scheme of immense proportions affected the S&L industry. Black makes it clear that a regulator, Edwin Grey, was partially effective in implementing regulations that ultimately revealed and stopped the frauds. Black argues that, without the regulatory response, and despite the interference that tempered the response, the systemic risk generated by the frauds would have spread through the economy and a global debacle not unlike the current global financial crisis might have taken place. Black's real message is clear: in the aftermath of the S&L crisis he thought U.S. regulators had learned a lesson and would vigorously enforce anti-fraud regulations. But subsequently crises with similar causes occurred. His books and papers and subsequent events suggest that government and the regulators failed in their responsibility to protect the public from fraud and the financial risks that accompany them.

Another spectacular debacle occurred in the early 2000s and included the Internet and telecom bubble and the demise of Enron. The literature (Fox 2003) suggests Enron was essentially a financial Ponzi scheme where inflated estimates of the lifetime profits from contracts were booked as income in a single year (Fox 2003). In additions, Enron booked income from derivative investments whose values were tied to the Enron share price, creating a huge risk of loss, should the price go down. The fictitious income created fictitious capital that could then be leveraged to fund more high-risk and ultimately unprofitable deals. Enron engaged in a number of high-risk derivative transactions that were accounted for off balance sheet, thereby hiding the enormous risk from investors and bondholders. The power and reach of Enron was such, that a Wall Street analyst that gave Enron a negative rating was fired (*Washington Post*, 2002). In addition, legislation dubbed the "Enron Law" was incorporated into a commodities legislation that prohibited the regulation of derivatives. This not only delayed detection of the Enron fraud, but made a significant contribution to the current subprime crisis by allowing bankers and investment firms to create risky derivative products that escaped supervision.

In 2007, the current global financial crisis began to unfold. The crisis has had a number of manifestations. Initially, the most visible aspect of it was the subprime bubble. That is mortgage loans were made to people with poor credit where it should have been apparent that large numbers would be unable to pay their mortgages. (i.e., these mortgages had names

like "liar loans" and "NINJA (no income, no job, no assets) loans"). These loans were then used as the basis for numerous derivative products including CDOs (collateral debt obligations) and CDSs (credit default swaps). When the subprime bubble burst, its effect was magnified by the derivatives layered on top of them. It is widely believed that legislators and regulators had an enabling role, whether witting or unwitting in the debacle (Prins 2009; Galbraith 2010).

This paper will provide evidence of numerous similarities between the 1980s S&L crisis and the current global financial crisis (GFC) including:

- role of new "innovative" but risky securities
- unethical and sometimes illegal acts used to market the new securities
- use of growth to drive a Ponzi-like scenario
- co-option of legislators to get legislation favorable to those trading the securities
- co-option of regulators to inhibit investigation and enforcement that could prevent some of the damage if stopped earlier
- use of flexible accounting rules to hide the risk from investors and regulators
- excessive incentive compensation for executives and managers of companies selling risky and unprofitable financial products

Calvatia et al. (1997) compare the actions of principals involved in the S&L crisis to organized crime. They also argue that fraud was a significant factor in the S&L crisis that was probably involved in the majority of institutions that went bankrupt. Markopolos (2009) and Lewis (2009) present evidence of pervasive fraud in their investigations of the Madoff fraud (Markopolos 2009, 2010) and the derivatives involved in the GFC (Lewis 2010). This paper will summarize and supplement their evidence. It will expand on Black's claim that fraud is a significant risk to the financial system and that systems to monitor and regulate fraud, as well as strict enforcement of current laws are needed, in order to prevent further serious crises.

1.1 Research Context

Since the inception of the global financial crisis (GFC) in 2007, the actuarial profession has been engaged in research to understand its causes and develop procedures to mitigate and prevent future global crises including recommendations for systemic risk regulation. One of the earliest North American actuarial publications to dissect the causes of the financial crisis is *Risk Management: Current Financial Crisis, Lessons Learned and Future Implications*

sponsored by the Joint Risk Management Section (JRMS) of the Society of Actuaries, Casualty Actuarial Society, and Canadian Institute of Actuaries. The book, published in December 2008, presents a number of useful insights and theories on the causes of the crisis as well recommended actions to prevent future crises. Critics of the risk management failure, a failure that allowed the financial crisis to occur, have suggested that risk management efforts be abandoned as futile. However, the contributors to the eBook felt that "real" risk management had not failed and that financial services companies should not abandon their efforts to identify and control risk. "If Greenspan's critics are right, and we must look to rating agencies and regulators to define the risks and how to measure them, then ERM will likely never amount to more than a game of minimizing the reportable magnitude of externally specified risk measures. Unfortunately, that seems to be how it has been practiced until now by many companies, including some highly touted for their superior risk management prowess."[2]

Many of the essay authors believe that the banks, brokers, and insurance companies that were principals in causing the crisis did not make a genuine attempt to implement risk management or develop a risk management centric culture. The following are some of the causes of the crisis the various authors cited:

- systemic failure of regulatory system
- lack of confidence resulting from accounting opacity and gimmickry
- a liquidity crisis partially resulting from "mark to market" accounting
- a bubble of historic proportions that could have been predicted from information available to bank managers and regulators at the time
- lax underwriting standards
- companies that were too big
- too much leverage
- inappropriate use of models without consideration of their limitations and without scrutinizing their assumptions for reasonableness
- moral hazard resulting from transferring risk to others, through securitization, leading to a complete failure to underwrite and manage the risks
- compensation incentives that encouraged taking on imprudent risk exposures

[2] Wacek 2008, page 26.

- Lack of[3] a reliable source of independent information.
    - In the case of subprime mortgages and the credit agencies, due to conflicts of interest, the information was not independent, and essentially only one view, an optimistic one was tolerated
- "[E]xcesses had been building up for a while throughout the financial system"[4]
    - Those who warned of the coming crisis were punished or ignored.

The JRMS also sponsored a research project, "The Financial Crisis and Lessons Learned for Insurers," (Klein et al. 2009). The project placed primary blame on the key assumption utilized both by modelers and the banks when they assessed and priced the massive risk that caused the crisis. That assumption was that housing prices never go down, at least on a national basis. "This optimistic belief was shared by policymakers, economists, and market participants in general, permeated the models used by rating agencies to assign inflated ratings to securities built from subprime mortgages, and was reinforced, for a time, in market prices through a self-fulfilling prophecy."[5] The authors also separately assign some blame to regulators and the credit rating agencies.

The issue of the operational risk lessons learned from the financial crisis is discussed in another JRMS-sponsored project, "A New Approach for Managing Operational Risk," (OpRisk Advisory 2009). The authors suggest that the "principal-agent" risk played a key role in the financial crisis and was the primary cause of the AIG credit default swap debacle. The authors note that the operational risk approaches currently in use do not address principal-agent risk, and therefore leave their companies vulnerable to significant losses from it. The concept of principal-agent risk relies on the idea of asymmetric information[6] between the agent and the principals. It is the risk that an agent, such as a chief executive officer, manager, or other employee, will expose the company to risks that are harmful to the company and its stakeholders but beneficial to themselves. The authors distinguish the principal-agent risk from the risk of criminal wrong-doing, as shown in Table 1.1. The authors define both criminal and malicious acts and principal-agent acts as acts of intentional wrongdoing. A key difference in definitions is that the criminal and malicious acts are intended to be at the expense of another party (such as the agent's company), but the

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[3] Ingram (2008)
[4] Rudolph 2008, page 31.
[5] Klein et al. 2009, Executive Summary.
[6] Asymmetric information means that the agents have access to information that the stakeholders do not. For instance, if the management of a company uses off balance sheet structures to suppress information about the risks they are taking, thy are privy to information that is not available to shareholders, customers and taxpayers.

principal-agent acts may nominally benefit the firm but are not in the firm's best interest. In addition those engaged in criminal acts expect a monetary benefit, while, based on these definitions, it is not as clear that a monetary benefit is expected by agents. Thus, the main distinction between a crime and principal-agent acts is that criminals intend to harm their victim and principal-agents do not[7].

Table 1.1[8]

Criminal and Malicious Acts	Events where the perpetrator(s) engages in a conscious act of wrongdoing, where he/she intends to benefit him/herself at the expense of another party. Criminal acts involve events were the perpetrator expects to receive a monetary benefit. Examples: Theft, fraud. Malicious acts involve events where the perpetrator also expects to benefit, but the benefit is of a non-monetary kind. Examples: Vandalism, terrorism.
Principal Agent Acts	Events where the perpetrator(s) engages in a conscious act of wrongdoing, which may nominally benefit his/her firm, but which are not in the firm's best interest. Example: falsifying or misrepresenting underwriting information to secure additional clients.

Another related term appearing in the literature exploring the causes of the financial crisis is "moral hazard." Moral hazard explains why a group of people intentionally take on risk when they are shielded from the consequences of the risk. An example would be a policyholder with a low deductible or no deductible engaging in more accident-prone behavior than a policyholder with a high deductible.

[7] OpAdvisory, page 33.
[8] From OpRisk, "A New Approach to Operational Risk." page 32.

Walker (2009) points out that in insurance the principal of *uberrima fides* or "utmost good faith" governs insurance while that of caveat emptor, or "let the buyer beware" had come to govern the rest of the financial services industry. This may explain a sharp difference between how insurance companies and banks are regulated and in how the managements in these industries behave.

This paper takes the view of Black (2008) that a key cause of the financial crisis is a more significant and dangerous risk than is implied by terms such as "moral hazard" or the principal-agent problem, and that many of the principals to the crisis participated in transactions that they knew to be abusive and even illegal, but because they did not believe they would incur adverse consequence for themselves personally they did not care about the consequences to others including their companies. Black (2005) argues that the subject of fraud is poorly understood and rarely researched by economists, and that therefore many misunderstandings prevail and guide official policy with respect to regulation. One of the misunderstandings that Black believes is not backed by the empirical data is that the market forces are sufficient to identify and address fraud, so regulation and enforcement are unnecessary. The economic theory claims that in transactions between two knowledgeable parties, fraud will ultimately be detected and eliminated, as it is not in the best interests of the potential victim to relax their vigilance. Black argues otherwise, that often the actual victim is a bondholder or shareholder who is not a party to the fraud decisions and not in a position to detect and stop it. He argues (Black 2008) that tolerance of fraud creates a "pathogenic environment" that spreads fraud.

In this paper we will make no distinction between criminal acts and principal-agent acts. The commonality between the two, intentional wrongdoing, whether illegal or not and whether the harm was intended or not is the focus of this paper. We will refer to the wrongdoing as fraud and corruption. We also believe that many of the factors cited in the JRMS essays and research papers, such as regulatory failure and wildly inappropriate assumptions, are manifestations of an environment that is so tolerant of fraud and abuse, as to cause it to become widespread in mortgage lending and investment banking.

1.2 Systemic Risk

This section contains a discussion of systemic risk, as the relationship between fraud and systemic risk is a key focus of the paper. The literature contains a number of definitions of systemic risk. A common definition is risk to an entire system or sector. This is typically conceived as a risk involving financial institutions, but other systems, such as the electric grid, can also suffer systemic risk. This is the definition used by Wang (2010). Under this

definition, the underwriting cycle in property and casualty insurance is an example of systemic risk. During the downward or "soft market" phase of the underwriting cycle, systemic factors that cause the P&C industry, in the aggregate to underprice insurance, causing industry wide income loss and declines in capital, affecting all companies in the industry (even those who do not underprice) and typically causing an above average number of supervisory interventions and bankruptcies.

Hiemestra[9] focusing more on financial institutions and their role in the financial crisis, defines systemic risk as "the probability that a large number of firms, especially financial firms, could fail during a given time period." He states that the "too-big-to-fail" financial institutions impose a systemic risk because their failure imposes a cost to society generally. Hiemestra noted that limited liability corporations are granted an option to "put" their losses to their creditors in the case of a bankruptcy, but a "too-big-to-fail" is given an option to put their losses to the taxpayer and continue functioning suggesting that government guarantees create a moral hazard that increases systemic risk.

Another definition of systemic risk is that it is a risk that spills over into and has a significant effect on the general economy. In the words of Weiss (2010), "systemic risk is a risk of adverse consequences that reverberates across a large segment of the financial sector as a whole, posing a potentially grave effect on the economy." The Property Casualty Insurance Association (PCI 2010) believes that "unusual and extreme federal intervention" is a manifestation of the potential danger of the risk to the economy. This is a more stringent definition that requires a broad-based impact on the economy, and is exemplified by the Global Financial Crisis that began in 2007 and led to government bailouts of a number of large corporations in 2008. Thus, even though subprime mortgages had declined in value, they would not have been a systemic risk absent the widespread damage to the general economy.

Weiss considers whether the insurance industry present a systemic risk. In investigating this question, Weiss attempts to determine whether certain events that could be catastrophic to the insurance industry such as the collapse of a single large insurer, widespread default by the reinsurance sector or a large catastrophe could spill over into the overall economy. Weiss identifies seven factors as key indicators of systemic risk. These are:

- **Size:** A very large company may pose a systemic risk if its bankruptcy can have a significant impact on the economy, i.e., it is "too big to fail."

[9] ERM-II May 2010 Systemic Risk Workshop

- **Substitutability:** If one product or company can substitute for another (i.e., catastrophe bonds for catastrophe reinsurance) there is substitutability. The absence of substitutability can be an indicator of systemic risk.
- **Interconnectedness** or **Contagion:** This occurs when a stress to one company causes a domino effect on other companies that share components of each other's liabilities. The LMX London reinsurance spiral, where the same loss to a primary insurer cycled through many reinsurers because each had a share, is an example.
- **Concentration:** This occurs when one or a few companies control a large percentage of an important product. It can also involve geographic or type of product concentration. When a large percentage of mortgages and mortgage derived securities were concentrated in the subprime sector, the entire financial system became vulnerable to a failure of this product.
- **Liquidity:** Liquidity is the availability of a market in a security even in a distress situation. For instance a problem with the financial crisis is that not only can mortgages be illiquid, but the derivatives of mortgage securities became unsellable. The crises of Lehman Brothers and Bear Stearns were in part due to their inability to rollover short-term financing once the market lost confidence in them.
- **Infrastructure:** The financial institution or sector is a critical component of the functioning of the larger economy, i.e., it is part of the infrastructure. Banks are an example of this, as financial exchange cannot occur without banks.
- **Leverage:** This term in finance refers to the asset to capital ratio. In property and casualty insurance leverage often refers to the liability-to-capital ratio. The use of leverage multiplies the impact of declines in assets or increases in liabilities. The higher the leverage, the higher the risk. For instance, the derivatives based on mortgage-backed securities contained significant leverage and many of the institutions that precipitated the crisis were highly leveraged, exacerbating the effect of the crisis.

Weiss examined each of these factors and concluded that the insurance industry is not a generator of systemic risk. For instance the there is no one insurance company that is large enough to cause a crisis if it fails, insurance has relatively low barriers to entry and other products can substitute for insurance, insurance companies are not extremely interconnected to other parts of the economy, do not show significant concentration, have relative modest leverage compared to banks (especially P&C), and most of their assets are liquid. On the other hand, Weiss believes insurers are vulnerable as recipients of systemic risk, as their asset portfolios, and for life insurers, some of their products, can (and did) suffer significant declines in a financial crisis.

AIG, a company that in 2008 was the country's largest insurer, precipitated a government intervention in fall 2008 when it was unable to meet collateral demands on mortgage-related derivatives that declined in value as the subprime crisis worsened. Numerous financial institutions were AIG counterparties, and a widespread crisis was feared if the U.S. government did not intervene. Due to AIG's significant role in the financial crisis, a number

of people disputed the claim the insurance companies do not pose a systemic risk, using the strict (Weiss 2010) definition of systemic risk noted above.[10] Even though a relatively small financial products division caused the AIG crisis, not its insurance division, some are not persuaded that this lets the insurance industry off the hook. It has also been noted that the product that brought AIG down, credit default swaps, was, for all practical purposes, an insurance product, even though it is not classified as such or regulated as such.[11] Though this paper does not focus on the role of AIG or of credit default swaps in the crisis, AIG serves as an example of the way systemic risk will be treated in this paper: that is, Weiss's stricter definition of a financial institution-caused-crisis that can affect the functioning of the broader economy, causing distress not only to other financial companies but potentially to the broader economy.

1.3 Objective

The objective of this paper is to explore the role of fraud and corruption in the global financial crisis (GFC) that began in 2007. We will review the history of the Savings and Loan crisis of the late 80s and early 90s and provide evidence that fraud played a major role in that crisis. We will also show that there were many similarities between the S&L crisis and the GFC, but that the scale of the GFC was dramatically different, partially because of regulatory intervention in the 1980s to mitigate the S&L crisis. This paper will show that regulatory lessons that should have been learned from the S&L crisis were not. It will then explore several aspects of the global financial crisis including (1) the subprime mortgage crisis and associated derivatives, (2) the Bernard Madoff Ponzi scheme, and (3) a theory of "looting" that explains the behavior of managers during the S&L and subsequent crises. We will present both statistical data and documentary evidence that fraud and corruption played a major role in the S&L crisis and GFC. We then discuss the systemic risk consequences of widespread fraud and corruption. Finally, we summarize our findings and discuss remedies.

1.4 Outline

The role of fraud in the Savings and Loan crisis is described in Section 2. The role of fraud in the global financial crisis is described in Section 3. The Madoff Ponzi scheme and the regulatory response to the scheme are discussed in Section 4. A description of a theory of "looting" is presented in Section 5. In section 6 the results of a financial fraud

[10] ERM-II Systemic Risk Workshop, May 11-12, 2010

[11] It also turns out that AIG had significant losses from a securities lending program in one of its life companies (Harrington 2010) though Harrington suggests this might not have caused a default.

survey are discussed. Results of all six sections are presented in Section 7. Conclusions and lessons are presented in Section 8.

2. THE SAVINGS AND LOAN CRISIS

This paper will argue that the Savings and Loan (S&L) crisis provided a model of the use of bank loans for fraud and presaged many similar business, regulatory, and legislative pathologies that occurred leading up to the GFC. Some background on the economic and regulatory environment of the time is provided.

Black (2005) describes the economic environment that set the stage for the S&L crisis. In the early 1980s, Federal Reserve Chair Paul Volker raised interest rates in order to reduce inflation. Because the Savings and Loan banks had a portfolio of long-term mortgages, issued for the most part many years earlier, at low fixed-interest rates, the increased rates caused a perverse effect on them. The market value of the assets fell dramatically, while the value of liabilities, which were much shorter term, did not. We illustrate this in Table 2.1, which shows the assets and liabilities (in millions of dollars) before and after an interest rate change. The very simple assumptions used were: (1) an interest rate increases of 3%, and (2) average duration of assets (mortgages) of five years. Interest rates increased from single digits to double digits in the early 80s. Therefore, these assumptions are somewhat moderate. Note also, that since most liabilities were primarily for short duration assets, such as saving accounts and CDs, in this simplified scenario the value of liabilities do not change after interest rates increase. The net result of the interest rate change is a market value decline in capital from $10M or about 5% of liabilities to -$19 M or 9% of liabilities. According to Black, by 1986, most S&Ls were insolvent by about 20%. When banks were willing to pay (i.e., not receive financial help from the regulators as an inducement) for taking over a troubled bank, no claims were made on the FSLIC's insurance funds to support the take-over, thus preserving the limited resources that the FSLIC had for shutting down failing institutions.

Table 2.1

	Assets	Liability	Surplus
Before	210.0	200.0	10.0
After	181.1	200.0	(18.9)

However because the agency responsible for insuring Savings and Loan institutions, the FSLIC, was underfunded and near insolvency itself, it resisted closing down failed banks,

preferring to support accounting approaches that allowed distressed banks to continue operation, and to merge or be purchased without infusion of federal funds. Since most banks initially had positive cash flows, recognizing the "true" condition of the bank could be delayed for years. Black (2005) makes it clear that under Pratt (an early 80s commissioner of the Federal Home Loan Bank Board) weak S&Ls were encouraged to purchase other weak S&Ls in order to eliminate a prospective insolvency of one of the institutions. This was accomplished by creating a "goodwill" asset as a result of the mergers and acquisitions (M&A) activity. Black considered the goodwill to be an accounting fiction. Table 2.2 displays an illustration of how goodwill is used to transform an insolvency into a viable business. Before the acquisition, both Bank A and Bank B are insolvent, as indicated by their negative capital. If Bank B purchases Bank A and records goodwill of $90M, the combined company after the merger shows a capital of $20M, an increase of $90M. The justification for the "goodwill" is that Bank B is willing to pay above market value for Bank A, and would only do so for the intangible "goodwill" asset. The circular reasoning is as follows: If a company was willing to pay more than market value (of assets minus liabilities) of a firm, this is proof that an additional intangible asset, i.e., goodwill exists. Black (2005) argues that the typical justifications for goodwill (i.e., customer relationships, synergy between merged firms, etc.) usually did not exist and that the goodwill was, in fact, an accounting device that permitted essentially bankrupt enterprises to continue operating.[12] Because the resources of the FSLIC were inadequate to support all the bankruptcies that in reality existed, regulators favored the device, although its real effect was to delay the recognition of bank insolvencies and worsen their severity. A pathological result was that since the banks were in fact insolvent on a market value basis, only incompetent and fraudulent managers were willing to pay far in excess of what the banks were in fact worth. Ingram (2009) refers to this as Gresham's Law of Risk: "[T]hose who do not see a risk will drive those who do see the risk out of the market." Gresham's Law is of course the same as the adage, "Bad money will drive out good."[13]

[12] In order for Black's assertion that the S&Ls were really insolvent to hold, one must also believe that the declines in asset values were not temporary, but were sustained and could not be worked out by waiting for values to return to a previous level.
[13] Ingram 2009, page 8.

Table 2.2

Before Bank Purchase

	Bank A	Bank B	Bank A + Bank B
Assets	165	165	330
Liabilities	200	200	400
Goodwill	0	0	0
Capital	-35	-35	-70

After Bank Purchase

	Bank A	Bank B	Bank A + Bank B
Assets	165	165	330
Liabilities	200	200	400
Goodwill	**90**	**0**	**0**
Capital	55	-35	20

Brumbaugh (2004) points out that, in addition to "goodwill," other accounting techniques, including overstatement of assets, were used. To support his argument that flexible accounting rules made a significant contribution to the S&L crisis, Brumbaugh supplied the information in Chart 2.1. Chart 2.1 displays the capital ratio for three different accounting conventions, Regulatory Accounting Principals,[14] Generally Accepted Accounting, and Tangible Net Worth derived by subtracting "goodwill" from the GAAP net worth. As a result of accommodative changes to regulatory accounting rules in 1980, the RAP capital ratio is the highest. The tangible net worth, which Brumbaugh regards as the most accurate, falls below 1% at the during the crisis,[15]

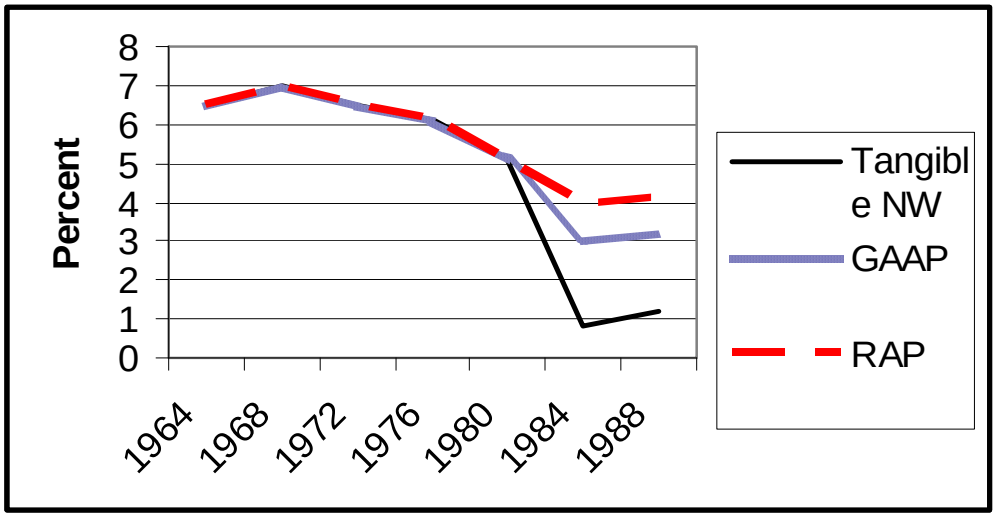
Growth was crucial to the strategy. The S&Ls that ultimately proved to be the most problematic grew rapidly by purchasing other companies, including non-bank companies and investing in low-quality risky projects, often not in their core area of mortgage financing. Financing for the high-risk ventures was acquired through brokered certificates of deposits and junk bonds.

[14] RAP is similar in concept to statutory accounting principles in insurance. However, based on Black (2005) it was less conservative than GAAP.

[15] Black (2005) notes that three of the big eight accounting firms and many law firms involved in assisting the S&L frauds.

Chart 2.1

Percent of Capital to Assets for RAP, GAAP, and Tangible Net Worth[16]



Black (2005) and Calavita et al. (1997) believe that because regulators favored this use of goodwill, ultimately incompetent and fraudulent purchasers were attracted into the S&L industry, as rational business managers would not pay more than a company was worth to acquire it. In Black's words (2008), "the regulators created a criminogenic environment." If the banks could be used as a vehicle to sell seemingly profitable loans, and extract significant fees and incentive compensation based on the loans, acquisition of a distressed bank was rational. That is, it was rational, until no more funding could be found to grow the bank's business, and the cash outflow for liabilities exceeded the cash inflows from assets. "High risk heavily concentrated investments with grossly inadequate or non-existent underwriting are highly unprofitable from the point of view of a profit maximizer not engaged in fraud. They are profoundly rational, however, from the viewpoint of a manager committing fraud."[17] A typical example of the frauds involving S&Ls was ADC or acquisition, development, and construction loans. The scheme involved a 100% loan from a bank to a builder (i.e., no down-payment) who also posted no collateral, and received lavish up-front fees and proceeds before the project even began. The loans often required no interest or principal payment for a number of years. The loans also generated high fees to the bank

[16] The figures in the chart are estimated from the graph on page 88 of Brumbaugh (2004). That graph was from Barth (1991).
[17] Calavita et al. 1997,page 39.

which were then booked as profit so S&L executives could pay themselves well from the "income" they generated from the construction company. Often, the S&L took an equity position in the project. Many of the construction projects were never completed, and some were never begun, even though the S&Ls booked significant profits from them. An "aha" moment occurred when then Federal Home Loan Bank Board Chair, Edwin Grey, viewed a video of acres of partially built (and abandoned) construction projects in Texas financed by ADC loans. Until that time Grey had had a strong antiregulatory, laissez faire stance. Grey wanted legislation passed to eliminate some of the accounting and investment abuses used in the ADC loans. One of these was the direct investment rule, which would prohibit equity investments in the businesses which were loan customers.

Black (2005, 2008) coined the term "control frauds" to describe what he saw in the S&L industry as a regulator.[18] With control frauds, those committing the frauds have control of their company. They also control many other resources needed to keep the fraud going such as lawyers, accountants, appraisers, and lobbyists. The perpetrators of the S&L frauds, such as Charles Keating, orchestrated an extensive lobbying effort against the regulators. Black (2005) documents the scheming that was used to restrain the Bank Board from intervening to close down the frauds. "One of the great advantages that white-collar criminals have over blue-collar criminals is the ability to use top lawyers even before criminal investigations begin."[19] An August 1985 letter, uncovered during litigation, from a lawyer with a prominent lobbying firm provided a relatively frank and somewhat shocking description of the strategy[20] to interfere with regulatory enforcement. The memo includes a plan to have the Reagan administration dismiss Edwin Grey, Bank Board Chair, who was proceeding with enforcement, and replace one or more Bank Board members with someone selected by Keating. Reagan ultimately did not dismiss Grey, so then Keating and his allies implemented a plot to pressure him to resign and destroy the effectiveness of the Bank Board. Typically the Bank Board chair has a lot of say in selection of fellow commissioners on the Bank Board but this was denied to Grey. The plan was to pressure the president into appointing Keating's selection by holding his top priorities (tax and budget bills) hostage.[21] [22] Due to this and other pressures and interference, the loyalty of regulatory staff diminished further weakening Grey and the Bank Board staff that favored a strong regulatory response. The

[18] Black was a lawyer with the Bank Board at the time of the S&L crisis.
[19] Black,2005, page 66.
[20] Black 2005, page 65.
[21] Two Senators who were beholden to Keating and part of the Keating Five were used to influence the appointments, as they could hold key legislation hostage.
[22] In actuality, the appointments were made in exchange for an appointment to a U.S. Court of Appeals. One of the appointments fell through (because of a scandal involving the appointees).

memo also described a plan to get the "Keating appointee" to persuade other Bank Board members to join him in opposing Grey. Keating also used litigation to prevent regulators from closing down known frauds. The Keating Bank Board members opposed Grey at congressional hearings. Keating also orchestrated congressional hearings to embarrass Grey, in part by supplying planted questions.

One of the members of congress who worked with Keating was Jim Wright. Wright was vulnerable to manipulation because he wanted to be House speaker. Keating and his allies created a political action committee (PAC) to elect Wright. The PAC was run by Tom Gaubert, who, according to Black, ran a control fraud, the bank Independent American.[23] Wright intervened repeatedly on behalf of the S&L frauds. Wright successfully pressured Grey on behalf of Craig Hall, a borrower who was insolvent by $1B. Another example involved Don Dixon of Vernon Savings, regarded as one of the worst control frauds in the nation. Dixon bought Vernon without putting up any of his own money. After regulatory action against Dixon was initiated, Representative Robert Eckhardt phoned the FBI director to find out who authorized subpoenas against Vernon and to convey Wright's displeasure. Another representative called the Bank Board and requested they not help the Justice Department. The Vernon bankruptcy ultimately cost the taxpayers $1B. Some of the additional regulatory interference that Keating and other S&L owners implemented was:

- The Bank Board was coerced to block aggressive interventions against known frauds by field offices.
- The Bank Board was forced to hire back an incompetent manager who was sympathetic to the control frauds. The Bank Board was required to give the employee a significant raise.
- The Bank Board was forced to sign an agreement to cease and desist in its investigation of Lincoln Savings.

According to Black (2005) this level of regulatory interference was unprecedented.

In addition to the interference with regulation, Wright also interfered with legislation to reform S&L accounting and regulation[24] to prevent abuses.

After Grey's term expired he was not reappointed and Danny Wall, who was favored by the control frauds, replaced him. Wall had no experience in supervision and believed the S&Ls could grow out of their solvency problem and worked to delay regulatory intervention

[23] At one point it lost " $1M a day."
[24] Known as the FSLIC recap bill.

against the frauds.

Despite the significant publicity given to the S&L crisis and the prosecution of some of the most high-profile operators of insolvent S&Ls, there is not wide agreement as to the role of fraud in the crisis. Calavita et al. (1997) express concern that revisionist economics has de-emphasized the role of fraud, instead blaming the economic environment, poor regulation, and poor (but not intentionally fraudulent) management. Calavita et al. provide statistics to support their claim that fraud was a major, if not *the* major factor in the S&L crisis. Table 2.3 is based on data in Calavita et al. (1997). The information in Table 2.3 shows that for the majority of banks under Resolution Trust Corporation Control (because they were taken over by the government) a criminal referral was filed. Though Calavita et al. recognize that a referral is not a conviction, they point out that referrals were not made unless significant evidence of a crime existed. They also note that many frauds that occurred were probably not recognized and referred.

Table 2.3: Statistics From S&L Crisis

	Total	Ca	Tx
Institutions Under RTC Control	686	59	137
Institutions Where A Criminal Referral Was Filed	455	42	85
Percent	66%	71%	62%
Referrals	2,265	175	631
Individuals Named on Referrals	4,559	223	1,350

From Table 2, p38, Big Money Crime by Calavita et al.

Calavita et al. compares the S&L frauds to organized crime. Their data suggests that while the frauds involved insiders, they also required networks of outsiders, including lawyers, accountants, appraisers, lobbyists, and legislators. Calavita et al. conclude that the thrift frauds constituted a kind embezzlement. "Most important, hot deals and looting[25] comprise a kind of hybrid crime, corporations against corporations or collective embezzlement."[26] They distinguish between the S&L frauds and other kinds of white collar crime, by pointing out that corrupting government by influencing the legislative and

[25] Hot deals involved investments in trendy, ultimately overpriced projects, such as commercial real estate, where the repeated selling of the same properties drove its price up dramatically. Looting involved investments in projects with little prospect for positive return, in order to generate fees and the appearance of profit.
[26] Calavita et al., page 171.

regulatory process was an integral part of the frauds.

Black supplies the following list of characteristics common to control frauds including the Enron and WorldCom scandals (Black 2010):

1. Fast growth
2. Extreme leverage
3. Lending to the uncreditworthy
4. Misuse of accounting, in particular inadequate reserves

Black believes (2009, 2010) that the subprime crisis was also an example of control frauds. What transforms control frauds into a risk to the financial system is the co-operation of various branches of government (i.e., legislative and executive) through favorable legislation and/or regulatory forbearance.

Both Calavita et al. (1997) and Black (2005, 2008) warn that failure to regulate against fraud creates an environment that significantly increases the probability that fraud will occur. When the companies managed by control frauds come to dominate, as in the case of the Savings and Loan institutions, contagion is created that can devastate an entire industry and even the financial system of a country. Black (2008) believes that regulators must act like public health experts and constantly search for pathologies (especially criminal pathologies) that have the capacity to spread and cause severe crises. Calavita et al. and Black are critical of economists, who in their view supplied the theory that was used to suppress regulation, even in the face of empirical data suggesting that fraud was a significant problem. Black uses Grey as example of a regulator who performed like a public health expert. "Grey reconceptualized the crisis, recognizing fraud, not interest rate risk, posed the gravest danger. The agency identified the correct problem over the universal opposition of economists by developing a new methodology, reaching the right analytical conclusions from the data provided by the new methodology, rejecting the conventional theories that form the core of modern finance theory, and developing a coherent theory of control fraud."[27]

3. THE SUBPRIME CRISIS

As noted in the introduction, the role of fraud in the GFC appears to have received less attention than other factors. In this section a combination of data and literature review will be used to support a claim that fraud played a key role in the GFC.

[27] Page 5 of (Black 2008).

One of the questions we address is, "should the banks, brokerage companies, credit rating agencies, and regulators have known how risky the mortgages underwritten were?" A number of studies (Francis and Prevosto 2009; Barnett-Hart 2009; Carson and Dastrup 2009) argue that data and techniques widely available at the time could have been used to forecast problem loans and to alert underwriters to the deterioration of their loan portfolios. Data and information collected from a number of sources will be used to illustrate this.

In a 2008 Casualty Actuarial Society VALCON[28] list e-mail, Gary Venter distributed foreclosure rates for cohorts of subprime mortgages organized by origination year.[29] The data was originally from Barth (2008).[30] Venter noted that when the data are transposed, they have the form of a loss development triangle, a standard tool applied by property and casualty actuaries to estimate ultimate liabilities. He provided some qualitative insights and conclusions that could be drawn by an actuary from the information. Expanding on Venter's suggestion, below are the results of applying the standard chain ladder technique to the foreclosure data.

The cumulative foreclosure rate triangle is presented below with one adjustment to the original data: the incremental values on the diagonal, which were evaluated as of September, were divided by 0.75 to bring them to an annual basis, consistent with all the others entries. For the adjustment to be reasonable, the defaults must occur uniformly throughout the year. This assumption likely does not hold and is a limitation of the analysis affecting the uncertainty of the results.

[28] The VALCON list is a list sponsored by the Committee on the Theory of Risk of the Casualty Actuarial Society and is a list that is subscribed to by actuaries and insurance professionals. The community of subscribers share research, ideas and musings related to the **Val**uation of **Con**tingent obligations.
[29] Barth et al. were the original source of the data.
[30] The actual data was from First Core Logic. See www.loanperformance.com.

Table 3.1

	Cumulative Default Rates @12/31/07								
	Development Age								
Year	1.000	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000
1999	0.013	0.076	0.131	0.179	0.202	0.223	0.231	0.236	0.239
2000	0.015	0.084	0.144	0.177	0.202	0.214	0.221	0.225	
2001	0.019	0.090	0.148	0.191	0.209	0.221	0.228		
2002	0.011	0.066	0.111	0.135	0.151	0.158			
2003	0.008	0.050	0.081	0.103	0.114				
2004	0.009	0.048	0.064	0.089					
2005	0.010	0.074	0.136						
2006	0.026	0.128							
2007	0.040								

Table 3.2[31]

Age-toAge Factors

	Development Age								
Year	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	Tail
1999	5.869	1.714	1.371	1.128	1.101	1.035	1.024	1.012	
2000	5.573	1.719	1.233	1.141	1.059	1.033	1.018		
2001	4.876	1.644	1.285	1.099	1.056	1.029			
2002	6.150	1.691	1.213	1.116	1.052				
2003	6.049	1.627	1.276	1.107					
2004	5.570	1.344	1.383						
2005	7.577	1.845							
2006	5.005								
Average	5.834	1.698	1.294	1.118	1.067	1.032	1.021	1.012	
Selected	5.800	1.700	1.300	1.100	1.067	1.032	1.021	1.012	1.0453
Age to Ultimate	16.779	2.893	1.702	1.309	1.19	1.115	1.08	1.058	1.0453

Before performing an analysis, observations can be made from the data on the triangle. Note that the relatively mature years of 1999 through 2001 have cumulative default rates in the vicinity of 25%. This appears to be quite a high rate for a period that preceded the financial crisis and was presumably a more rational period for mortgage loans. What may be surprising to many is that a subprime mortgage business flourished in the 1990s. However, most of the companies involved experienced difficulties and disappeared before the real estate bubble of the 2000s was under way. Lewis, in *The Big Short* (2010), describes how two Wall Street analysts uncovered major problems with the 1990s subprime companies. In 1997, the analysts, Steve Eisman and Vincent Daniels acquired a Moody's database with information about the subprime industry. While the database did not have loan level details,

[31] The inverse power curve was used to derive a tail.

it contained descriptive statistics about the loan portfolios of the subprime companies. In particular, the database contained default and prepayment statistics. Daniels noticed extremely high prepayment statistics for the manufactured housing category. He determined that the prepayments were really defaults classified as "involuntary prepayments." Because mobile homes start to depreciate in value as soon as they are purchased, significant losses were realized on the loans. "Eventually I saw that all the subprime sector was either prepaying or going bad at an incredible rate. I was just seeing stunningly high delinquency rates in these pools."[32] Daniels continued to analyze the data over a number of months for additional insights into the industry. He eventually concluded that the entire subprime industry was distressed, but through a combination of growth (to get fresh investment cash) and creative and misleading accounting, the industry avoided the recognition of their condition. Lewis (2010) notes that ultimately most of the 1990s subprime lenders went bankrupt. One of the subprime lenders from the 1990s, Long Beach, was purchased by Washington Mutual (WaMu) and wrote billions of dollars in subprime loans during the housing bubble. An e-mail from Long Beache's regulator at the Office of Thrift Supervision (OTS) claims that it was one of the 13 worst institutions in 1997 through 2003 (Levin 2010). In 2003, the company had so much trouble that WaMu temporarily stopped securitizations from it. However, operations were soon resumed, and Long Beach was to cost WaMu many billions of dollars in losses.

The difficulties of the early subprime lenders received little notice, probably because their size was small relative to all financial assets in the global economy. Nonetheless, there was historic evidence of losses and bankruptcies in the recent past from subprime mortgages.

In order to gain insight into the default problems of more recent origination years, ultimate default rates will be estimated. Table 3.3 displays the application of the age-to-ultimate factors, to the diagonal (as of yearend 2007) cumulative foreclosure rates to estimate ultimate foreclosure rates for each origination year. Estimated ultimates derived from the chain ladder method, or any other actuarial development techniques are very uncertain. The estimates are considered especially unstable for data of low maturity, such as that of the 2007 and 2006 years. Moreover, some of the assumptions underlying the chain ladder are violated, adding yet additional uncertainty to the estimates. Using the chain-ladder technique, foreclosure rates are estimated to be nearly 40% for 2006 and over two-thirds for 2007. In other words, the estimates of ultimate default rates suggest that the majority of subprime loans from 2007, along with a very large percentage of 2006 loans will default.

[32] Lewis 2010, page14.

Table 3.3

Default Rates Developed to Ultimate

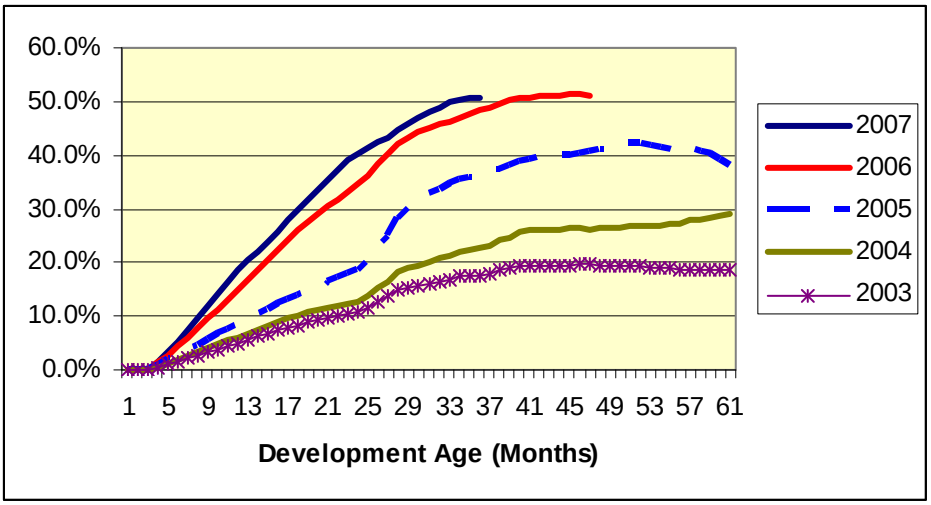
Year	*Current Year End Defaullt Rate*	*Age To Ultimate*	*Ultimate Default Rate*
	(1)	*(2)*	*(3)=(1)*(2)*
1999	0.239	1.058	0.253
2000	0.225	1.058	0.238
2001	0.228	1.080	0.246
2002	0.158	1.115	0.177
2003	0.114	1.190	0.136
2004	0.089	1.309	0.117
2005	0.136	1.702	0.231
2006	0.128	2.893	0.371
2007	0.040	16.779	0.673

Notes:
(1) All rates adjusted to 12 month basis by dividing by 0.75

Among the many limitations of the data that were not taken into account were origination year, calendar year, and economic effects that will impact future development patterns and violate the assumptions of the chain ladder, i.e., that the development patterns are constant over time. Nonetheless, the simple technique, using data from September 2007 gives an early indication of significant default rates in pools of subprime business. More recent information was obtained from LoanPerformance.com.[33] Figure 3.1 displays the development over time of loans 60 or more days past due for pools of Alt-A and subprime mortgages. This data suggests that as of 35 months of maturity the number of loans in or near "default" already exceeds 50% for the 2006 and 2007 years.

[33] The data supplied by e-mail and is the December 31, 2009, valuation.

Figure 3.1
Mortgages 60+ Days Past Due



Assuming that there is some recovery (40% is a typical recovery assumption on defaulted bonds (Altman, Kishore, 1996))[34] after foreclosure, these rates portend massive losses on the subprime-backed securities. Moreover, the analysis of data in the triangle, suggest that the possibility of significant default rates could have been predicted from past data, especially if history from the 1990s when many subprime writers became insolvent, were included. From the analytical perspective, the research of Demyanyk and Van Hemert (2008) suggests a significant degradation in loan quality in 2006 and 2007. According to Demyanyk and Van Hemert, the deterioration in foreclosure rates should have been known to the mortgage lenders as early as 2005, based on loan information that is routinely collected. Their analysis applied logistic regression to loan level data and found that the quality of loans declined for six consecutive years. For instance, their data indicates that the percentage of loans with balloon payment, and the percentage of loans with no documentation grew dramatically over time. Demyanyk and Van Helmert also observe that their model indicates that low subsequent price appreciation (and depreciation) contributes about 2 to 4 percentage points to default rates 12 months after origination. They state: "Problems could have been detected long before the crisis, but they were masked by house price appreciation." Francis and Prevosto (2010) also provide evidence that using data available at the time, potentially problematic mortgages could have been identified before loans were approved. In addition to showing simple descriptive statistics that provided early warning of loan portfolio deterioration, they provide examples of data mining procedures that could have been used to

[34] The securities backed by the subprime mortgages were packages rated and marketed as if they behaved like bonds. Many of the lenders may have expected almost full recovery on defaulted assets based on the mistaken belief that housing prices never go down.

predict the likelihood of default on loans.

Moreover, the default problems with subprime mortgages appears to be inherent in their design, as they apparently were not designed to be held to maturity, with interest and principal being completely discharged by the debtor. Gorton, an advisor to AIG, describes the subprime based securities in a paper (Gorton 2008), which indicates that serial refinancing was intended and built into the product when the mortgages were sold. To protect the lender from the "risky borrower," the loans were structured to be held for a relatively short period (two to three years) and then refinanced. As price appreciation of the underlying asset was expected, the refinancing was expected to occur before the rates of an ARM or of a mortgage with an initial teaser rate were adjusted upwards and the mortgage payment exceeded the debtor's resources. However, the refinancing was at the option of the lender so if houses failed to appreciate the borrower faced the risk of being stuck in a mortgage that under any realistic scenario exceeded his or her ability to pay. According to Gorton, "The appreciation of the house became the basis for refinancing every two to three years."

The view that subprime mortgages were not intended to be paid off is supported by others. Demyanyk (2009) notes that termination rates for subprime mortgages were relatively constant for origination years from 2001 through 2006. At 12 months of maturity, termination rates are about 20%, at 24 months they are about 50%, and at 36 months they are about 80%. However, when housing price appreciation slows, defaults grow as a percent of the terminations and refinancings decline. Demyanyk's analysis also indicates that the subprime lending was a net loss to homeownership; that when foreclosures are subtracted from the number of first-time buyers that obtained houses through subprime financing, the former exceeded the latter. Black accuses the subprime lenders of unethical behavior, likening them to used car dealers (2010). He accuses them of using aggressive sales tactics to sell mortgages to people who did not need them, did not understand them, and could not pay them.

Lewis (2010) describes how hedge fund manager Michael Burry witnessed the enormous price increases in San Jose and in 2003 decided that a housing price decline of historic proportions would eventually occur. "You have to watch for the level in where nearly unlimited or unprecedented credit can no longer drive the housing market higher." [35] Burry analyzed the statistics, such as percent with no documentation, loan-to-value ratio of mortgages, location, etc. before betting against the mortgage pools. He wrote that, "It is

[35] Lewis 2010,. page 47.

ludicrous to believe that asset bubbles can only be recognized in hindsight."[36]

Thus the subprime mortgages were very vulnerable to declines in housing prices. Yet a core assumption of pricing and rating (Lewis 2010; Muolo 2008) was that housing prices would never decline. Taleb in his book *The Black Swan* (2007) describes the fallacy of believing an event will never happen merely because it was not experienced or in one's data. Appropriate risk management would consider such events. Indeed, the housing price declines were not a "black swan" or rare event, as housing price declines in the United States have occurred in relatively recent years. Examination of publically available data would have shown the assumption to be unreasonable. Figure 3.2 shows the annual rates of change for housing prices based on the Case-Shiller index.[37] The chart clearly shows a decline in the late 1980s-early 1990s. Lewis (2010) describes the surprise of hedge fund investors when they learned that all the credit rating agencies shared the same two assumptions: housing prices would rise and loan losses, even for the lowest-rated securities, would be around 5% (with the 5% loss estimate strongly dependent on the price appreciation assumption).

Black (2010) refers to certain kinds of mortgages, such as those dubbed by the industry as "liar loans," as negative expected value products. That is, the product is structured so as to create adverse selection that guarantees a loss. This is the equivalent to selling an insurance product to substandard risks without underwriting the policyholders or examining historic data on their experience. Thus the enormous losses experienced on such loans did not constitute a rare event arising from extreme risk, but should have been the expected outcome.

Lewis also makes it clear that the rating agencies only did a cursory job of evaluating the mortgage securities underlying the pools they rated and refused to develop detailed databases that could have been used for a rigorous evaluation of mortgage loan portfolios. Levin (2010) and Black (2010) cite a memo of S&P management to their employees demanding that they not request loan level data from the companies, because they did not have it and because it would be unreasonable to do so. Muolo (2008) also notes that the rating agencies sometimes intentionally ignored data that did not agree with the assumptions of their models. "To judge from their behavior, all the rating agencies cared about was maximizing the number of deals they rated for Wall Street investment banks, and the fees they collected from them."[38]

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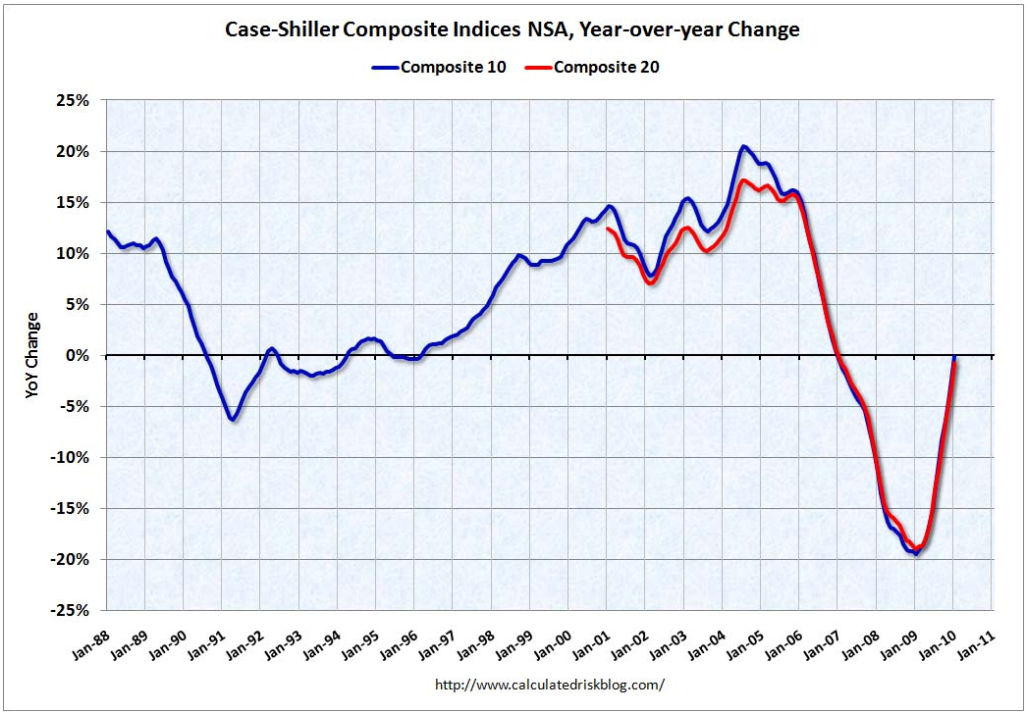
[36] Lewis 2010, page 54.
[37] The chart index from www.calculatedriskblog.com. The data is from the Case-Shiller index published by S&P.
[38] Lewis 2010,.page 157.

The evidence presented above indicates that, though the rating agencies were well paid for their work, they did not do a conscientious evaluation before assigning credit rates, and likely intentionally avoided negative information about the securities they rated, in order to maintain their fee income. Black (2009, 2010) accuses the rating agencies, as well as the managements of companies that securitized the loans of having a "don't ask, don't tell" policy that limited their exposure to negative data and information that would contradict the high quality ratings that were assigned.

Figure 3.2

Annual Change in House Prices[39]



Lewis (2010) makes it clear that the hedge fund managers he highlights, such as Eiseman and Burry, believed that the companies involved in selling the subprime loans and derivatives such as the banks, investment companies, and credit rating agencies, were not only inept, but were unethical. He describes how the investment banks devised strategies to convince the credit rating agencies to assign A or better ratings to subprime pools that did not merit the high ratings. These securities could then be packaged and sold to pension funds and ordinary investors as high-quality fixed investment products. He also cites the

[39]Graphic courtesy of www.calculatedriskblog.com.

statistic that by 2005 the FBI claimed that mortgage fraud had increased by 600% and more resources needed to be dedicated to the problem (they in fact were not). In 2004 CNN reported that the FBI warned of the potential for the mortgage fraud to become an epidemic (Frieden 2004).

First-person evidence of mortgage-related fraud is also supplied by Richard Bitner (2008). Bittner was a subprime lender for five years during the subprime peak. He sold his share of his mortgage business in 2005 when he noticed a marked deterioration in the quality of the loans and felt that the market was no longer rational. At the time he decided to leave, he was finding that about 70% of applications to his company contained some misrepresentation. In his chapter titled, "The Underbelly: Mortgage Brokers" (*Confessions of a Subprime Lender: An Insider's Tale of Greed, Fraud, and Ignorance,* Bitner, 2008), Bitner describes the deceptive tactics brokers used to get loans approved. In another chapter subtitled, "The Art of Creative Financing," he describes the methods used by brokers and mortgage banks to subvert conventional underwriting criteria.

The investigative journalism organization ProPublica (Eisinger and Bernstein, 2009) published a report describing how the hedge fund Magnetar colluded with brokers and investment banks to select some of the most toxic securities to be included in CDOs, which they then bet against using credit default swaps. Their investigation indicated that the Magnetar deals helped to keep the bubble going for an extra two years. Recently, the SEC has initiated a civil lawsuit against Goldman Sachs for a similar arrangement with the Paulson hedge fund, where Paulson selected assets for inclusion in CDOs based on their low quality. Ivry and Shenn (2010) describe a CDO-based fund, Davis Square III, that was created by Goldman Sachs and insured by AIG. Although AIG believed it had not undertaken any new CDS exposure after 2005, Goldman replaced the collateral in the fund with CDOs originating in 2006 and 2007 that were significantly worse in quality. Declines in the credit quality of the Davis Square III fund helped trigger collateral demands on AIG by Goldman and other counterparties. Ivry and Shenn suggest that the practice of collateral replacement may have been relatively common and that it constituted a "gotcha" that the writers of CDSs were unaware of.

Newspaper articles have also contained accounts of corrupt practices within the banks making loans. In a November 2, 2008, article titled, "Was There a Loan it did not Like?", *New York Times* reporter Gretchen Morgenson describes the travails of a senior underwriter at Washington Mutual who at the height of the bubble was pressured to approve loans that she felt were obviously flawed, and in some cases blatantly fraudulent. Several times her decisions were overruled at a higher level. On at least one of those occasions, after no

payments were made on the loan for six months, the "house" was discovered to be a vacant lot. She was also written up three or four times for rejecting suspect and flawed mortgage applications. "I swear 60% of the loans I approved I was made to," she said. According to Levin (2010) two of WaMu's most prolific and highly praised underwriters were found by an internal audit to be flagrantly violating the company's underwriting standards. The review found in 2005 that they "had an extremely high incidence of confirmed fraud" of 58% and 83% respectively.[40] Yet the auditor's recommendations were not implemented and two years later WaMu's insurers refused to insure any more loans produced by the two.

More evidence of fraud was uncovered by Fitch. After an exceptionally high rate of early defaults was observed for 2006 year loans, an audit was performed on a sample of subprime loans originated that year. The audit found evidence of fraud in the overwhelming majority of loans sampled (Fitch 2007), including 16% where identity fraud was indicated.

Black (2009) notes that creative accounting typically plays a major role in supporting control frauds and believes it played an important role in the GFC. A high-profile example is provided by Lehman, which hid the true extent of its leverage using a repurchase arrangement (Valukas 2010) that removed assets from the balance for a short period of time at the end of quarters, so that it would not appear in published financial statements. Black (2010) stated that the New York Federal reserve was aware of some of Lehman's accounting manipulations, made adjustments to assets for their own evaluations, but did not require Lehman to adjust its published financials. Black suggested that this was by intent, that, "the Fed didn't want Lehman and other SDIs (Systemically Dangerous Institutions) to sell their toxic assets because the sale prices would reveal the values Lehman (and all the other SDIs) placed on their assets were inflated with worthless hot air."[41]

In 2004 Fannie Mae and Freddie Mac were investigated for using derivatives to smooth earnings and hide losses. Crum (2004) reports that Fannie used the "Accumulated Under Other Comprehensive Income" (AOCI) technique to hide losses from the prepayment of mortgages. Crum also reports that Fannie Mae had a history of failing to disclose the true extent of its losses from interest rate swaps. Sowell (2009) reports that members of congress intervened on behalf of Fannie Mae and Freddie Mac on numerous occasions to prevent regulation and intervention to reign in accounting irregularities and excessive risk taking (such as lowering of underwriting standards, use of derivatives and extremely high leverage). Seymour (2008) claims that the accounting problems at Fannie were 19 times those of

[40] Levin (2010), page 7.
[41] Black (2010), page 12.

Enron but received relatively sparse press coverage. Because Fannie is a significant underwriter of mortgages (recently 90% of the secondary market and 50% of the total mortgage market according to Seymour) these irregularities allowed it to make a significant contribution to the housing bubble. In 2008 (see Figure 3.3) Fannie and Freddie were placed in conservatorship by the U.S. government.

In this section we have presented evidence that the mortgage banks, GSEs such as Fannie Mae, investment banks, and credit rating agencies had ample information to determine the low quality and high risk of subprime loans before the crisis became one. Evidence suggests that accounting rules were used to hide losses and high-risk investments. The failure to properly evaluate and account for the mortgage-based securities was egregious. Documentary accounts and eyewitness evidence suggest that the failure was not due just to ineptness, but to greed and fraud.

Figure 3.3 Fannie Mae Stock Price Before/After Bankruptcy[42]

During the period in which the S&L crisis was developing, insiders who caused the crisis influenced the political process to support legislation favorable to the frauds, to prevent regulations from being enforced, and to interfere with criminal investigations. The issue of the role of legislators and the regulators will be addressed more extensively in the next section of the paper.

[42] Graph courtesy of http://finance.yahoo.com/.

4. THE MADOFF PONZI FRAUD

As noted by Povel et al. (2005), the general wisdom is that financial frauds tend to occur during bubbles and be revealed when the bubble bursts. The Madoff Ponzi scheme fits this model, in that it was perpetrated during the 1990s and 2000s and collapsed in late 2008 as the financial crisis created a demand for cash by investors. A question raised by both Markopolos (2009, 2010), the Madoff whistleblower, and numerous others (Helyar et al. 2009) is "should the regulators and the managers of funds that invested in Madoff have known?" With respect to the SEC, Markopolos suggests the answer should be an emphatic "yes." Using data from one of the Madoff feeder funds, Francis and Prevosto (2010) present a number of simple descriptive statistics and graphs that could be used to assess the reasonableness of Madoff's claimed returns. Some of the statistical results they present are:

- Histograms of the Madoff returns compared to other assets shows a distribution unlike any of the other assets (including bonds and stocks).
- Descriptive statistics of the Madoff returns (mean, standard deviation, and skewness) deviated sharply from those of other assets.
- A tabulation of the percent of months with negative returns showed that the Madoff fund had a fraction of the negative returns compared to other assets.
- Scatterplots of the Madoff returns versus the returns of the S&P 100 showed virtually no correlation, when a positive correlation should have existed. (Madoff's fund allegedly was invested in the S&P 100 along with some options to limit both the downside and upside returns and therefore there should have been a correlation).

The reader is encouraged to review the graphs and descriptive statistics in Francis and Prevosto (2010). In addition, a few additional statistics will be presented in this paper. . In Table 4.1, which was motivated by Markopolos (2009, 2010), we note that the Madoff fund has both a higher mean return and a lower standard deviation of return than the other asset categories. A statistic known as the Sharpe ratio[43] is used to measure the return of an investment compared to its risk as measures by the standard deviation of the return. Markopolos (2010) noted that the apparent Sharpe ratio for the Madoff fund was well outside of the range of expectations. One of Markopolos's "red flags" was that a Madoff fund whose returns he reviewed had an extraordinarily high Sharpe ratio. Figure 4.1 presents the distribution of excess returns from a Madoff feeder fund and four other asset categories.

[43] The Sharpe ratio is a risk-adjusted return that measures the excess return, or the return excess of a risk-free rate, relative to the standard deviation of a return series (Maginn and Tuttle, 1990).

The asset categories used in the graph and tables here are the same as those used in Francis and Prevosto and are:

- The Madoff feeder fund returns are from the Fairfield Sentry Fund. This fund is referenced by Markopolos (2010) and is referenced on the book's resource Web site www.noonewouldlisten.com.
- The S&P 500. Because it contains 500 stocks instead of the 30-35 in Madoff's fund, it should have lower volatility (standard deviation) than the Madoff data.
- The S&P 100. This is the index Madoff claimed his fund tracked. Because it contains 100 stocks instead of the 30-35 in Madoff's fund, it should have lower volatility (standard deviation) than the Madoff data.
- A Balanced Fund that contains a mixture of equities and income producing investments. One would expect to have lower volatility than an equity index (S&P 100).
- A long-term bond fund. One would expect low volatility for this fund.

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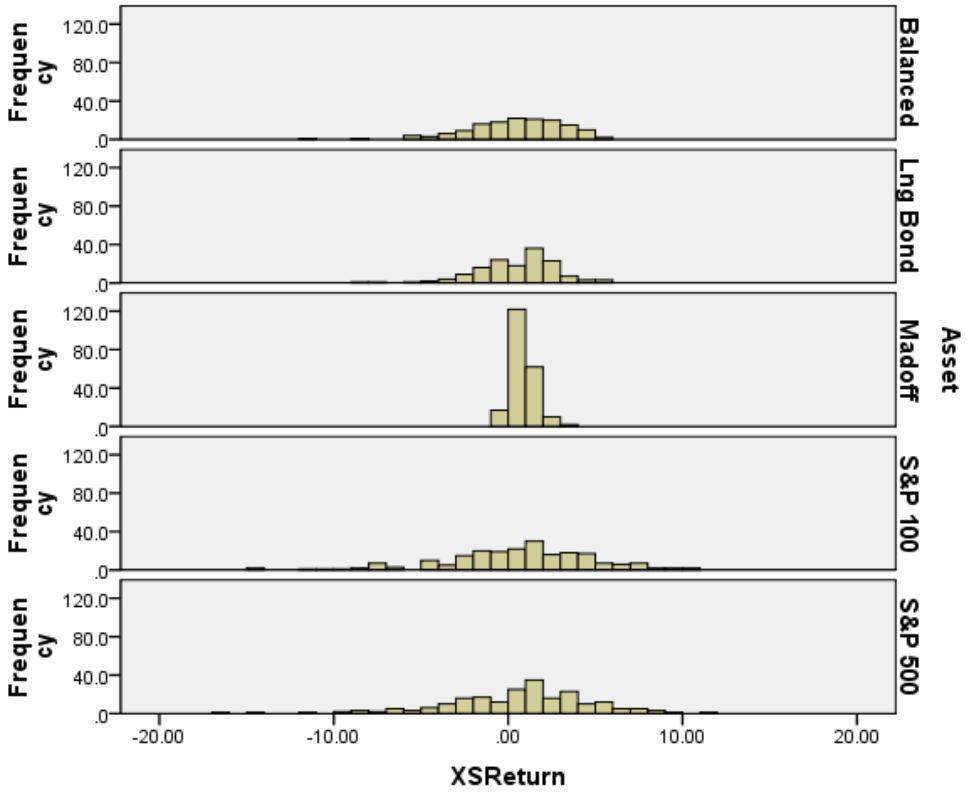
Figure 4.1

Distribution of Excess Return by Asset Type[44]



The histograms in Figure 4.1 depict the excess returns for the various asset return series. The excess return is defined as the one-month return for the asset minus the one-month return on a three-month Treasury Bill. The distribution of the Madoff returns stands out as being very different from those of the other series. For each of the series above, the mean excess returns and return standard deviation were computed and were used to compute a Sharpe ratio. These are presented in Table 4.1. Table 4.1 shows that the Madoff fund has a Sharpe ratio that is an order of magnitude or nearly so (in the case of the long bond fund) greater than that of the other investments. Markopolos (2010) claimed that this should have been an indication that the Madoff returns were "too good to be true."

[44] The data underlying the calculations in this graph were obtained from http://finance.yahoo.com/.

Table 4.1 Sharpe Ratio

Asset Category	Mean	Std. Deviation	XS Return	Sharpe Ratio
(1)	(2)	(3)	(4)	(5)=(4)/(3)
Balanced	0.46%	2.84%	0.0049	0.05
Lng Bond	0.60%	2.40%	0.0054	0.12
Madoff	**0.84%**	**0.70%**	**0.0084**	**0.75**
S&P 500	0.55%	4.15%	0.0061	0.06
SandP100	0.57%	4.27%	0.0060	0.06

Note: Asset return series were downloaded from http://finance.yahoo.com/.

A number of other "red flags" were also noted by Markopolos and others (New York Attorney General Complaint, 2009) include:

- A very large hedge fund was using a small unknown accounting firm.
- All assets allegedly were sold by December 31 of each year and invested in treasuries.
- Madoff's description of his strategy changed very little over time, while other investment manages needed to update strategies periodically.
- There was no evidence of the trades that Madoff purportedly made. For instance, it was a huge fund and sale of all assets at the end of the year would be noticed. Markopolos (2010) states that a Bloomberg terminal could have been used to quickly and easily to verify that trades claimed by Madoff were in fact made.
- After option costs, Madoff's strategy could not have beaten T-Bill returns (Markopolos 2010; Forray 2009).

One of the things a Ponzi set-up needs to continue to exist is a high growth rate. Table 4.2 presents a scenario where the amount invested in a Ponzi fund more than doubles every year for 16 years, although the growth rate declines starting at year 13 and all growth stops in year 18. Even with a relatively high takeout rate for fees (to feeder fund managers) and cash redemptions (30% in this scenario) the assets of the fund can continue for years. The Ponzi scenario is compared to the alleged cumulative return of the Madoff fund in Figure 4.2. Note that the Ponzi scenario and the Madoff fund track each other quite closely for 16 years,[45] but once the growth rate drops below the fee/redemption rate, the two diverge sharply. When the Madoff returns are compared to those of a real asset, in this case the S&P

[45] The growth and redemption rates were intentionally selected to produce results that would be similar to the feeder fund.

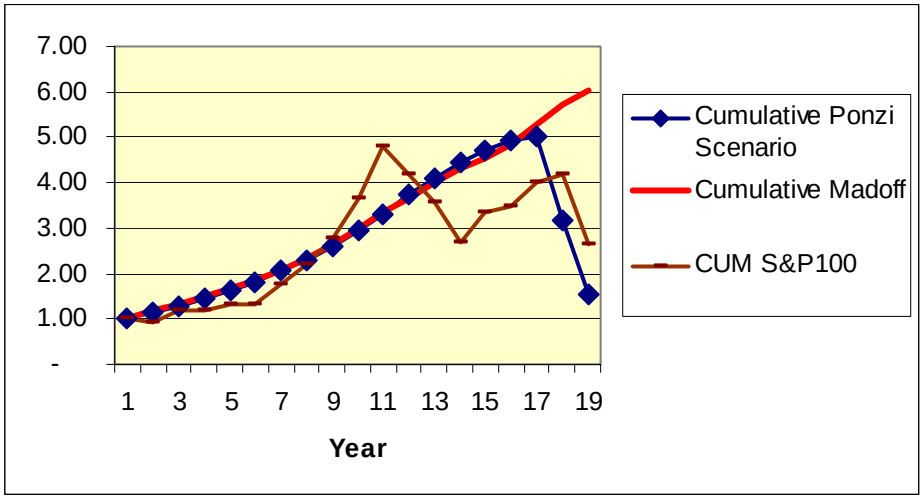
100, the Madoff fund displays a smooth, sharply rising increase (see Figure 4.2). This is another of the "red flags" Markopolos mentions.

Table 4.2 Ponzi Scenario Math

Period	Cumulative Amount in Fund	Gross Growth Rate	Fee & Redemption Rate	Net Growth Rate	Cumulative Ponzi Scenario
1	1,000.00	2.300	30%	1.61	1.00
2	1,127.00	2.300	30%	1.61	1.13
3	1,270.13	2.300	30%	1.61	1.27
4	1,431.44	2.300	30%	1.61	1.43
5	1,613.23	2.300	30%	1.61	1.61
6	1,818.11	2.300	30%	1.61	1.82
7	2,049.01	2.300	30%	1.61	2.05
8	2,309.23	2.300	30%	1.61	2.31
9	2,602.50	2.300	30%	1.61	2.60
10	2,933.02	2.300	30%	1.61	2.93
11	3,305.52	2.300	30%	1.61	3.31
12	3,725.32	2.25	30%	1.58	3.73
13	4,114.46	2.21	30%	1.55	4.11
14	4,453.37	2.16	30%	1.52	4.45
15	4,723.80	2.12	30%	1.49	4.72
16	4,910.43	2.08	30%	1.46	4.91
17	5,002.35	1.300	30%	0.91	5.00
18	3,186.49	1.000	30%	0.70	3.19
19	1,561.38	1.000	30%	0.70	1.56

Figure 4.2

Ponzi Scenario,. Madoff Fund and Stock Index Cumulative Returns



A question posed at the beginning of this section is "should the SEC and hedge fund managers have known that the Madoff hedge fund was a fraud?" Markopolos (2010, 2009) and the New York Attorney General (2009) are among those who say "yes." Some of the evidence has been briefly summarized above suggests that it would have been relatively easy to determine that the returns that Madoff claimed could not be real. If this is the case, then why did so many investment professionals and regulators fail to perform due diligence? In a Bloomberg special report, Helyar et al. (2008) suggest that many hedge fund managers did believe that the Madoff returns and or strategy were phony. Helyar et. al. found that at least some fund managers believed that Madoff was engaging in a type of fraud known as "front running." That is, as Madoff had a widely used electronic trading operation, these managers believed that when an order came in Madoff "front ran" the order, or manipulated the bid ask spread to skim off extra profits for his hedge fund. Markopolos also describes a trip to Europe to discuss investments in a fund he managed. On the trip he learned that many of the wealthy European investors who had invested with Madoff believed that he was front running and were reluctant to invest funds with another manager, unless they could match the Madoff returns.[46] Arvedlund (2009) reports that during one of the rare investigations by the SEC, Madoff coached the management of the Fairfield Fund on strategies for responding to SEC questions.[47] They were instructed to say that Madoff was only executing strategies at their direction (even though Fairfield knew that they were just turning the funds

[46] When grilled by the management of his own company as to why he could not invent a product to match Madoff's returns, Markopolis repeatedly insisted that it was impossible, as Madoff's returns were not real (Markopolos, 2010).
[47] Arvedlund, page 214.

over to Madoff and had virtually no participation in the strategy). Madoff also warned that the SEC would likely be concerned that he was front running. The Fairfield management collaboration with Madoff on the SEC investigation was successful. Markopolos (2010) also reported learning that many professionals at investment banks and brokerages suspected the Madoff returns were fraudulent. For instance, AIG investigated making an investment in the Fairfield fund and declined after concluding that he was front running. Markopolos states, "The question I have struggled with…is why did so many people allow this fraud to continue for so long? The industry knew, there's no question about that."[48] Markopolos indicates that front running is a widely occurring abuse that is openly tolerated. "It has been my experience that front-running is common in the broker-dealer business. It's a form of insider trading that the SEC tolerates because they know they can't stop it. They would successfully catch two or three cases a year…Meanwhile they let thousands of cases to continue unmolested."[49]

Markopolos (2010, 2009) also describes his frustration resulting from his many encounters with the SEC that yield no meaningful results. Table 4.3, which is abstracted from his 2009 testimony,[50] presents a timeline of Markopolos's efforts to persuade the SEC to act on the Markopolos fraud. Markopolos was able to determine in five minutes that the Madoff returns were phony. It took another four hours to prove it. Over the next eight years he approached the SEC five times. The SEC ultimately initiated an investigation (hence Madoff's coaching of Fairfield management) but it was cursory and resulted only in citations for paperwork that was not properly filed. According to Markopolis (and others) the SEC is largely staffed with inexperienced people who hope to spend a few years at the agency and then work for the companies they are regulating. Most of the people are lawyers, and therefore there is a lack of expertise in relevant professions (accounting, statistics, finance, investments) needed to conduct a rigorous investigation in today's environment. Markopolos, along with Patrick Byrne, (founder of the Web site deepcature.com[51]) and others, believes that the SEC has been captured by the industry it regulates, and that it protects the predators. Markopolos even describes how the SEC created a whistleblower program, not to assist potential fraud whistleblowers but to allow companies to complain about "overzealous" enforcement.

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[48] Markopolos 2010, page 176.
[49] Markopolos 2010, page 52.
[50] Markopolos 2009, pp. 27-29.
[51] See www.deepcapture.com for more details on allegations of fraud not covered in this paper.

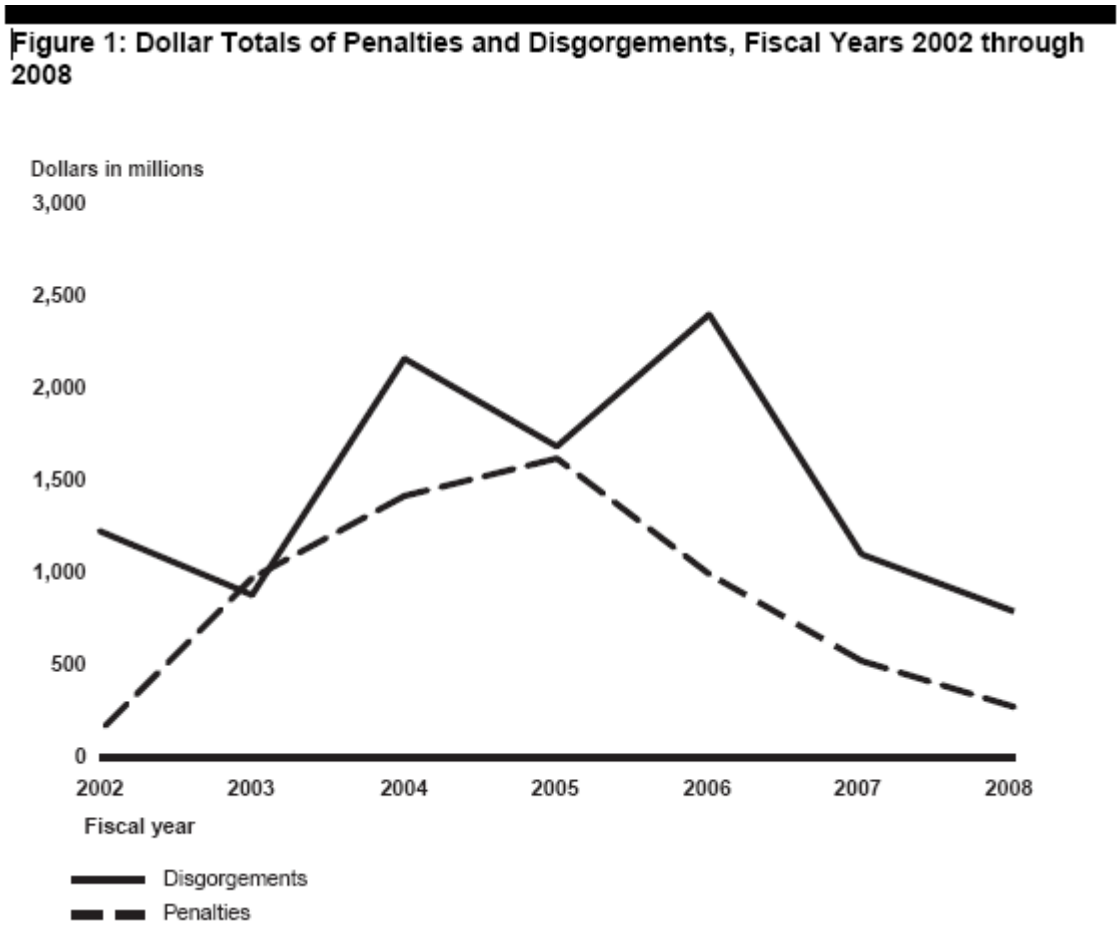
Table 4.3. Timeline from Markopolos Testimony

Date	Activity
Late 1999	Frank Casey "discovers" Bernie Madoff (BM). Rampart tasks me to reverse engineer BM's strategy.
Early 2000	4 hours of research proves mathematically that BM is a fraudster.
May 2000	8-page submission to SEC Boston Regional Office's Director of Enforcement.
Jan 2001	Michael Ocrant starts researching the BM story for *MarHedge.*
May 2001	Michael Ocrant publishes "Madoff Tops Charts; Skeptics Ask How."
Sep 2001	SEC's Ed Manion calls to ask me to re-submit the Madoff case.
Oct 2001	2nd SEC Submission consists of original 8-page May 2000 submission+ 3 additional pages + 2-page Investment Process Explained.
2002	Investigation continues: e-mail records lost.
June 2002	Key marketing trip to London, Paris, Geneva, and Zurich where I discover that Europeans are likely BM's largest investors.
2003	Investigation continues: e-mail records lost
2004	Investigation continues: e-mail records lost.
June 2005	Frank Casey discovers that BM is attempting to borrow money at European Banks—the first indication that the scheme is running short of $.
Oct 2005	SEC's Ed Manion arranges for third case submission. I meet with Boston SEC Branch Chief Mike Garrity. SEC's Mike Garrity investigates.
Nov 2005	SEC's Mike Garrity puts me in contact with New York SEC. Third SEC Submission to SEC.
Dec 2005	I start to doubt NY SEC and contact *WSJ* Washington bureau.
Jan 2006	Integral Partners' $40 million derivatives Ponzi scheme goes to trial 5 years and 5 months after its discovery, causing us to further doubt SEC competence.
Sep 2006	Chicago Board Options Exchange Marketing VP tells me that several OEX option traders also believe that BM is a fraudster.
2007	Neil Chelo obtains Feb 28, 2007, portfolio of BM trading positions; portfolio shows no ability to earn a positive return.
June 2007	Frank Casey obtains Wickford Fund LP prospectus showing that BM is now so short of cash that he is offering a 3:1 leverage swap to obtain new funds.
June 2007	This prospectus is e-mailed to NY SEC..
July 2007	Neil Chelo obtains Greenwich Sentry LP Financial Statements for 2004-06; Auditors are different for each of the three years, which is very odd.
Aug 2007	Neil Chelo has opportunity to interview Fairfield Sentry's head of risk management, who displays a startling lack of acumen.
Aug 2007	Hedge funds all have losses this month except for BM—he's amazing!
2008	Global markets dive; entire investigating team loses interest and is busy with more pressing matters.
April 2008	Jonathan Sokobin, SEC's Director of Risk Assessment, calls me per the recommendation of a mutual friend.
April 2008	I send Sokobin my last SEC submission and quit the investigation.
Fall 2008	Stock markets crumble; panicked investors rush to redeem.
Dec 2008	Madoff "confesses" and turns himself in after running out of cash to meet investor redemptions.

A GAO report concluded that a culture existed within the SEC that deterred the initiating of cases and demand for penalties when investigations confirmed fraud. The GAO reports that between 2002 and 2008, the number of investigative attorneys was reduced by 11.5%. Burdensome approvals were needed to pursue investigations. SEC attorneys could not enter negotiations for penalties without prior approval for the amounts. Figure 4.3 (from the 2009 GAO report) displays the trend of disgorgement and penalties. The graph shows a dramatic decline in amounts after 2005. This along with Markopolos's first-hand experience suggests a policy of tolerating fraud. Tibman (2009) reports that hostility to regulation was an SEC core conviction, and "as currently constituted the SEC is incapable of competent oversight."[52] Further support that regulatory agencies ignored fraud for a long period of time, under both Democratic and Republican administrations is provided by Brooksley Born, a head of the CFTC under Clinton (Zacchino et al. 2009). Born warned about the dangers of derivatives, and tried to regulate them in the late 1990s. In a conversation with Alan Greenspan, she was told that he was opposed to regulating fraud. She also clashed with Lawrence Summers and was eventually pressured to resign because of her pro-regulatory stance. Her story suggests that regulator forbearance towards fraud existed for at least a decade before the financial crisis.

[52] Tibman 2009, page 75.

Figure 4.3 From 2009 GAO Report on SEC titled, "Greater Attention Needed to Enhance Communication and Utilization of Resources in the Division of Enforcement"



Source: SEC

5. THE MATHEMATICS OF FRAUD

There is very little literature evaluating the costs versus benefits of financial fraud. Akerloff and Romer (2005) developed a theory of "looting" that shows that under some regulatory environments managers of financial institutions maximize their personal profits by "looting" the institution they manage. Unlike standard economic theory, the development of the model assumes that irrational markets can and do exist and that they can persist for long periods. The development also assumes that the government may wittingly or unwittingly support the perpetration of irrational behavior.

To motivate the theory, they develop a simple three-period model. It is a model of the value of a bank as loans are made and obligations that fund the banks investments, such as savings deposits and CDs are undertaken. At time zero a firm had liabilities L_0, Assets A, and accounting net worth W, which in the simple model is supplied by the owner-managers. At times one and two they pay themselves dividends d_1 and d_2 (which denote all forms of

extracted wealth, whether legitimate or due to fraud). The bank also receives income $\varrho_1(A)$ and $\varrho_2(A)$ from its asset (i.e., loans). The looting model assumes the government will lend unlimited amounts to the company. In words the model is:

Value at time 0 = Discounted period 2 net value+ period 1 dividends

Final (Period 2) value = Period 2 Assets – Period 2 Liabilities

Period 2 value = period 2 income from assets - (period 0 Liabilities – period 1 income + period 1 dividends) accumulated for interest + period 1 dividends

$$\max(V_0) = \max \frac{(\rho_2(A) - (1+r_1)(1+r_2)[L - \rho_1(A) - d_1]}{1+r_2} + d_1$$

$$\textit{subject to } 0 < cA_0 < W_0,$$

$$\rho_t(A_t) = \textit{cash payments}, d = \textit{dividends}$$

The government requires the company to maintain capital equal to *cA*. The formula can be reduced to show that a key decision variable for management is the assets purchased by the bank :

$$\max(V_o) = \frac{\rho_2(A)}{1+r_2} + \rho_1(A) - (1+r_1)L_0$$

$$\textit{subject to } 0 < cA < W_1$$

$$d_1 < M(A)$$

$$d_2 < \max\{0, \rho_2(A) - (1+r_1)[(1+r_1)L_0 - \rho_1(A) + d_1]\}$$

Assume the managers are the equity owners (in the case of the S&Ls ownership was often concentrated). Assume the government imposes a maximum M(A) on the dividends the company management can pay.

The owners maximize their "equity," which can be different from the true economic value:

$$\max(E) = \frac{d_2}{1+r_2} + d_1, E = \textit{owner's equity}$$

The government allows management to pay itself M(A), an amount that may be greater than or less than V. According to Akerloff and Romer if M(A) exceeds market value V, the management is incented to invest in negative return assets in period 1, and default in period 2. If necessary, it will borrow in period 1 to fund management dividends.

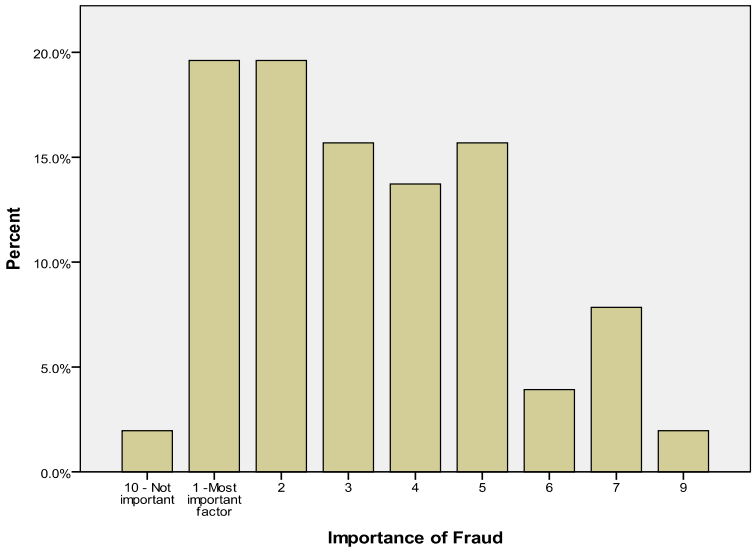
This differentiates looting from moral hazard, where managers expose their company to excessive risk, but anticipate a positive payoff. Akerlof and Romer offer several examples of looting. One of them is the Texas ADC loans where Akerloff and Romer maintain that no reasonable management would expect a positive return. Black (2010) believes the subprime crisis is also an example of looting, as the underwriters of mortgages with names such as liar loans and NINJA loans likely expected the loans to be unprofitable. Believing that through securitization the risk was laid off on others, the lack of profitability did not matter, but the substantial fees and compensation did.

6. THE FINANCIAL FRAUD SURVEY

In this section the results of an Internet survey on financial fraud are presented. The survey respondents are colleagues and friends of the author, who were contacted by e-mail. The sampling method used is not random, thus survey results may be biased. Due to the way respondents were solicited, approximately 50% of the respondents worked in the financial services industry. Nonetheless, some interesting results were obtained that may provide insight into how U.S. residents feel about financial fraud and what they think should be done to address it. The survey had six questions. Fifty-one people responded to the survey. The questions are shown in Appendix 1.

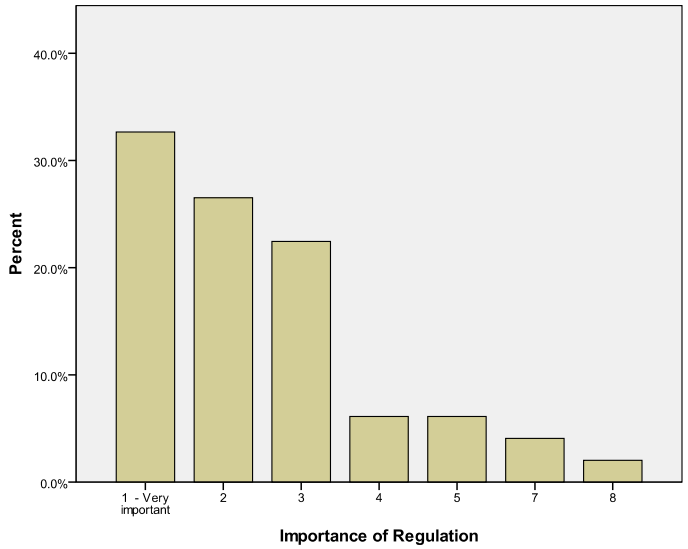
Question 1 ranks the importance of fraud on a scale from 1 to 10 with 1 being highest. The average score was 3.5, suggesting a concern about the role of fraud, but a belief that other factors are more important.

Figure 6.1 Importance of Fraud in Financial Crisis



Question 2 asked respondents how important they thought regulators were in the financial crisis. The respondents tended to rank the regulators very high and as more important than fraud. Over 30% of respondents ranked regulators as #1 in importance versus under 20% for fraud and over 50% ranked regulators #1 or #2. One respondent commented, "They [regulators] were important because they did not do their job and did not understand the markets well enough to see what was happening with the derivatives, hedge funds, etc. They were also important because of how Freddie/Fannie situation was used (abused?)." A number of other people mentioned poor regulation of Fannie and Freddie. Several respondents also mentioned that they thought credit rating agencies performed badly; one respondent mentioned that the credit rating agencies were an even more important cause than regulators.

Figure 6.2 Importance of Regulators in Financial Crisis



Question 3 asked respondents if they were a victim of financial fraud in the last five years. Approximately 23% said yes, with about 6% having been the victim of securities fraud. Though the survey sample was not random, this result indicates a significant minority of people have first-hand experience with financial fraud.

Table 6.1 Were you a victim of financial fraud?

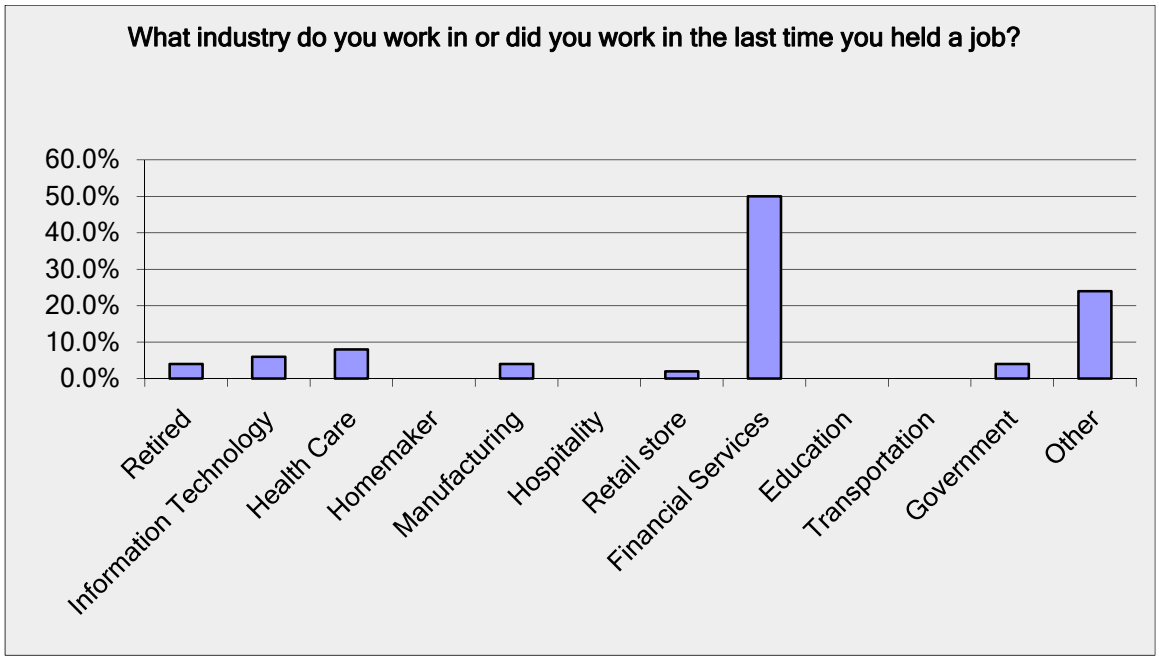
Were you or someone in your family, or a friend the victim of financial fraud in the last 5 years (i.e., in the period leading up to the crisis and its aftermath)?		
Answer Options	**Response Percent**	**Response Count**
yes – mortgage fraud	0.0%	0
yes – securities or stock fraud	5.9%	3
yes - other financial fraud	17.6%	9
not sure	13.7%	7
No	64.7%	33
Additional comment		6
	answered question	**51**
	skipped question	**0**

Question 4 asked if the respondent knew anyone who had committed financial fraud. Approximately 10% of respondents know someone who committed fraud in the past five years. One of the respondents who answered yes commented that "financial law enforcement is almost non-existent."

Table 6.2 Do you know someone who committed financial fraud?

Within the past 7 years, do you personally know an individual who committed financial fraud, whether or not they were charged with a crime?		
Answer Options	**Response Percent**	**Response Count**
Yes	9.8%	5
No	80.4%	41
not sure	11.8%	6
Additional Comment		3
	answered question	51
	skipped question	0

Figure 6.5 What industry do you work in?



Finally, respondents were asked what solutions they recommend to prevent financial fraud and corruption. Approximately two-thirds of respondents provided a write-in answer to this question. A number of people elaborated on various ways to more effectively and efficiently regulate financial institutions. These included eliminating the revolving door between regulators and the regulated and instituting oversight independent of the Fed and financial institutions. A respondent opined, "Our regulators are almost all political appointees (mostly lawyers), are generally clueless, and easily corrupted—anything else is an improvement." Several people wanted to restore prior laws from the 1990s that imposed

greater restrictions on financial institutions; presumably this included the Glass–Steagall Act that prohibited investment banks from owning banks. One person mentioned the older laws "prohibited gambling on mortgage-backed securities." Some respondents, however, were specifically concerned that more regulation would be counterproductive and that previous regulatory additions intended to deter fraud, especially Sarbanes Oxley, created a lot of extra effort without impacting the commission of fraud. In addition to regulators, lawmakers and the Federal Reserve were also fingered for contributing to the crisis.

7. RESULTS AND DISCUSSION

Sections 4 and 5 of this paper showed that abundant data was available to determine that:

- there was a housing bubble
- mortgages were deteriorating
- mortgage fraud was occurring and was rapidly increasing
- pools of subprime mortgages were granted high-quality ratings that they did not deserve
- Madoff was committing fraud

Rating agencies, the banks, and the SEC ignored this data. An S&P e-mail indicates that employees were specifically instructed not to request data. Section 5 supplies evidence that many fund managers suspected that Madoff was committing fraud, but they believed that the fraud would benefit them. Numerous authors, journalists, and investigators supplied evidence that many people realized that subprime mortgages and the related pools of mortgages (collateralized debt obligations) were unprofitable and that a significant increase in mortgage fraud was occurring.

Akerloff and Romer's theory of looting helps explain why the dominant economic paradigm with respect to financial fraud that deems regulation unnecessary, has repeatedly been refuted by the empirical data. Looting, as opposed to managing a business prudently, can be profitable. Looting may be legal (though it probably should not be). The author believes it can be viewed as a form of corruption. Akerloff and Romer show that profit-maximizing managers may pursue unprofitable business, even when it bankrupts their company and harms their customers and other stakeholders. Looting is profitable because the managers extract a large reward for themselves before the insolvency is recognized. The risk of looting rises under weak regulatory regimes where the risk of prosecution is low.

When looting occurs on a large scale, through Gresham's law, it comes to dominate an industry and a systemic risk develops. Looting occurred during the S&L crisis. The S&L looting involved cooperation between bank managers, their service providers such as auditors, and the government. Members of congress were actively involved in passing legislation that prolonged the fraud and interfered in law enforcement investigations of the perpetrators of fraud. The evidence in this paper also suggests that looting, i.e., devising and selling inherently unprofitable products, was a key cause of the GFC. Thus, a crucial component of the success of frauds in S&Ls was corruption of the legislative and regulatory process.

Interference with legislation helped to create the conditions for the GFC. In 1990s, the legislative process was used to eliminate last barriers (i.e., Glass Steagall eliminated with the passage of Gramm-Leach-Bliley) to reckless behavior by financial services companies. Changes to the Commodities Futures laws allowed derivatives such as the CDOs and CDSs that caused the crisis, to trade in the over-the-counter market exempt from federal regulation. Legislation also prohibited states from regulating these risky derivative products. Also federal government interference with enforcement of state's predatory lending laws removed barriers to development of debt products designed not to be paid off.

Some of the regulatory functions were outsourced to credit rating agencies, who failed to provide proper surveillance of mortgage quality. In addition regulatory agencies such as the SEC appeared to be reluctant to investigate cases of fraud, especially when high-profile members of the Wall Street elite were involved. The FBI, even though it recognized a mortgage fraud "epidemic" as early as 2004, was not given resources to pursue those committing the fraud.

8. CONCLUSIONS

In 1934 the results of the Percora investigation, a senate led investigation into the causes of the 1929 stock market crash were published. The investigation was high profile and received intense coverage by the press. The investigation found the fraud played a major role in the crash (Geisst 2005). One response was the Glass-Steagall Act, which separated banking, investing, and insurance. It was intended to remove the conflicts of interests that arise when the three functions exist within the same company. It was also intended to temper the political influence of some of the large financial conglomerates. Another response was the formation of the Securities and Exchange Commission, which was invested with authority to regulate and prevent fraud. Levin (2010) pointed out that some of

the corporations investigated by Pecora's commission were also participants in the GFC. Unfortunately, by 2000 Glass-Steagall was eliminated and the evidence suggests that the SEC was no longer providing meaningful regulation.

Systemic risk is a risk that affects a financial system, such as the savings and loan industry, that has the potential to affect a nation's economy (in the case of the S&L crisis) or the global economy in the case of the GFC. This paper presented evidence that fraud played a significant role in both crises. William Black is one of only a very few academics calling for routine monitoring for fraud and suggests that the SEC needs a chief criminologist. He points out the SEC is a law enforcement agency, but it is predominantly staffed with lawyers and economists with little expertise in fraud. He believes that the task of detecting fraud is relatively simple, as "red flag" indicators of fraud are well-known and the information required is relatively easy to gather and review. Black claims (2009) that the subprime-related frauds were cruder than the S&L frauds and therefore easier to prevent.

In August 2009 and May 2010, ERM-II (Enterprise Risk Management Institute International) held workshops on systemic risk. Participants discussed causes of the GFC, its impact on insurance companies, whether insurance companies can be vectors for systemic risk, and what changes to systemic risk regulation should be made., In general participants felt that insurance companies were unlikely to cause a systemic crisis, though a vocal minority argued that complacency is unjustified, as an insurance company, AIG, played a key role in the current crisis. They felt that the fact that it was a banking subsidiary, not the insurance operation that was responsible, does not negate its contribution. Vaughn[53] suggested that insurance regulators will close the loophole that allowed an AIG subsidiary to take on excessive risk and post inadequate reserves without disclosing the exposure to insurance regulators. As noted in Section 3, there is evidence that fraud played a role in the AIG debacle.

Vaughn also suggested that the insurance industry deserves a place in the discussion about systemic risk regulation, as the industry has been significantly affected by the GFC. As noted by Klein et al. (2009), life insurance companies were more affected than property and casualty companies through their variable annuity products and through investment portfolios more exposed to toxic mortgage products. While the workshop participants focused more on managing the financial industry's exposure to excessive risk-taking through regulation, a regulator with the Federal Housing Finance Board[54] emphasized the role of

[53] Terry Vaughn, president of the NAIC, in a presentation at the May 2010 ERM-II workshop.
[54] Dr Stephen Hiemstra, May 2010 ERM-II workshop.

fraud.

The author believes that actuaries are risk management experts who deserve a role in discussion about the causes and remedies to the financial crisis. The evidence presented in this paper suggests that fraud regulation needs to be a key component of Systemic Risk Regulation. The SEC needs a "chief criminologist," i.e., someone experienced in fraud detection and prosecution. More FBI resources are needed to investigate and prosecute financial fraud. When the subprime bubble burst, the FBI had only a fraction of the resources it possessed during S&L crisis. Regulators must search for and prosecute fraud. Increasing the emphasis on enforcement and on detecting fraud before it creates a system-wide crisis can be accomplished without any new legislation, though legislative changes in the late 1990s and early 2000s appears to have removed some barriers to fraud. The evidence presented in this paper suggests that if fraud is not addressed, future crises will occur.

Acknowledgment

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Abbreviations and notations

ADC, acquisition, development and construction,
CDO, collateralized debt obligation
CDS, credit default swap
ERM, enterprise risk management
GAO, General Accounting Office
SEC, Securities and Exchange Commission
SDI, Systemically Dangerous Institutions

Biography of the Author

Louise Francis is a Consulting Principal at Francis Analytics and Actuarial Data Mining, Inc. She is involved in data mining projects as well as conventional actuarial analyses. She has a BA degree from William Smith College and an MS in Health Sciences from SUNY at Stony Brook. She is a Fellow of the CAS and a

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Appendix 1: Financial Fraud Survey Page 1 of 2

Financial Fraud

*** 1. On a scale of 1 to 10 with 1 being most important and 10 least important, how important do you think Fraud and Corruption were in causing the financial crisis?**

	1 - Very important	2	3	4	5	6	7	8	9	10 - Not important
Importance of fraud	○	○	○	○	○	○	○	○	○	○

***2. Were you or someone in your family, or a friend the victim of financial fraud in the last 5 years (i.e. in the period leading up to the crisis and its aftermath)?**

- ☐ yes - mortgage fraud
- ☐ yes - securities or stock fraud
- ☐ yes - other financial fraud
- ☐ not sure
- ☐ no

Additional comment

***3. Within the past 7 years, do you personally know an individual who committed financial fraud,**
whether or not they were charged with a crime?

- ☐ yes
- ☐ no
- ☐ not sure

Additional Comment

4. On a scale of 1 to 10, how important do you think regulatory

agencies were in causing the financial crisis?

	1 - Very important	2	3	4	5	6	7	8	9	10 - Not important
Importance of regulators	○	○	○	○	○	○	○	○	○	○

5. What solutions do you recommend to minimize financial fraud and corruption?

6. What industry do you work in or did you work in the last time you held a job?

- ☐ Retired
- ☐ Information Technology
- ☐ Health Care
- ☐ Homemaker
- ☐ Manufacturing
- ☐ Hospitality
- ☐ Retail store
- ☐ Financial Services
- ☐ Education
- ☐ Transportation
- ☐ Government
- ☐ Other

List Other

Information, Market Behavior, and Valuation

Philip E. Heckman, Ph.D., ACAS, MAAA

Abstract: Responding to the recent financial crisis, this paper examines the role of information flow and transparency in the maintenance of orderly markets. Information plays a role in markets at two different levels: securities trading activity and fundamental values. Efficiency in securities markets is seen to depend on the availability and free flow of information. Even given good trading information, however, sparse or inaccurate information on underlying values can contribute to the formation of asset bubbles. This leads to an informal model of a securitized asset value as a superposition of pure trading asset and pure underlying asset. The relative importance of these components depends on the state of information in the market.

Information on underlying values comes largely from financial accounting. We identify certain defects in going-concern accounting information not addressed—and perhaps aggravated—by fair value and mark-to-market prescriptions. Valuation of liabilities is, and has always been, particularly problematic. Neither are going concern asset values that are the same as marking to market.

We adduce work by Wang and recent efforts of Madan and coworkers as possible conceptual tools for dealing with asset and liability valuation, concluding with an outline of a practical approach.

Keywords: Information, Financial crisis, Securities markets, Financial reform, Fair value accounting, Valuation.

"The dogmas of the quiet past are inadequate to the stormy present…We must disenthrall ourselves...."

—Abraham Lincoln

1. INTRODUCTION

One remarkable aspect of the recent financial crisis is the nature of the financial instruments and associated markets that brought it about. Debt securities collateralized by subprime residential mortgages (CDOs, etc.) and the credit default swaps (CDS), bought to hedge against default of these instruments, brought the nation and the world to the brink of a second Great Depression, which was staved off, for now, only by the most draconian of fiscal measures. These instruments had several common characteristics: (1) complexity, (2) over-the- counter (OTC) trading, and (3) heavy dependence on the integrity of agents, which, taken together, add up to extreme opacity.

These OTC markets have essentially no reporting requirements. Details of the transaction are known only to the direct parties. Brooksley Born, former head of the Commodity Futures Trading Commission (CFTC), coined the term "dark markets" to characterize them. The CDS market is very similar to a commodity futures market, where both benefits and obligations are transferred freely in an active secondary market and where speculative interest can outweigh insurable interest by a large multiple. In the CDS market, all this took place without benefit of an exchange, nor even a clearing

facility until March 2009, and regulation by the SEC or CFTC was proscribed by The Commodity Futures Modernization Act of 2000 (CFMA). The debates prevalent at this period are made clear by an exchange between Allen Greenspan and Brooksley Born in which Greenspan expressed the hope that Born would take little action against fraud while running the CFTC since he believed that the market itself would detect and punish fraudulent behavior. Born did not subscribe to Greenspan's view. This exchange exposes a fundamental split in the philosophies undergirding public policy. Does a "free market" mean a free-for-all, or does it mean a forum where persons can engage in commerce without spending large amounts of time, effort, and money to ensure that they are not being cheated? Many would say, that the former does not deserve to be called a "market" and that the term should be reserved for arenas of commerce governed by the rules of fairness and probity, which we tend to take for granted but which quickly disappear unless they are enforced by established authority. In cold terms of market efficiency, one need only cite the frictional costs of vigilance and due diligence imposed by a free-for-all approach to commerce. Can a market where every bank note has to be tested in a laboratory be called "free"? One doubts that Mr. Greenspan really supports such an approach and must rather suppose that he has a faith in the rationality of market participants that is beyond the capacity of most of us.

Mortgage-based securities have been on the investment menu for decades without causing material disruption. The new ingredients in the current crisis are the extremely low interest rates that prevailed during the last decade and the flood of investment capital resulting from tax cuts for the affluent and from the collapse of the tech boom of the late nineties. This latter produced a temporary disaffection with equities, and real estate came into fashion as a source of investment yield. This, combined with long-standing government policy in support of home ownership, implemented in part through Fannie Mae and Freddie Mac, fueled an unprecedented housing boom as well as a push on the part of mortgage lenders to market to borrowers of inferior credit quality in order to expand the market. Like most other mortgages, these subprime loans were pooled and tranched into mortgage backed securities (MBS), then repackaged into CDOs, resliced into tranches of varying putative quality, and blessed by credit rating agencies on the basis of certain assumptions as to their provenance, which turned out to be false. The resulting financial train wreck, starting in the shadow banking system and described in detail by Gorton (e.g., 2009a) brought about a systemic crisis from which the global economy is only beginning to recover. I shall draw freely on Gorton's masterful account of the role and dynamics of information in securities trading, a subject which he learned in part from bitter experience at AIG (Lewis, 2009).

What lessons can we learn from this debacle? In the following, I will make the case that markets depend on information for orderly functioning. Information is their nourishment and lifeblood. The OTC markets that precipitated the crisis were blind monstrosities, riddled with opacities and obstacles to free trading. To call them free markets is beyond disingenuous, much like maintaining that freedom is enhanced by the absence of law and order; and those who did so should have known better. We shall see that all securities have a dual nature as derivatives on the underlying values and can trade in two distinct modes simultaneously depending on the quality of information regarding the underlying values. This information comes predominantly from financial reports, and its quality in turn depends on the validity of the governing accounting principles and their application. We shall find that the fair value and mark-to-market prescriptions imposed by the accounting standards bodies, relying as they do on spot prices, lead to valuations premised on prompt liquidation of the enterprise, and are by no means assured to be appropriate for valuing a going concern. The adjustments required to get to a going-concern-basis lead to discussion of the insolvency put, with its implications for valuation of liabilities, and of the more subtle issue of the option to defer redemption of an asset.

In order to make this case we shall review and comment on the foundational work on the efficient market hypothesis. We shall then examine the tension between fundamental estimates of the value of a firm and the value placed on it by the equities markets and the role of information quality in deciding the behavior of equities. We also review briefly the work on bond spreads and the relative roles of credit risk and liquidity risk. The question of restoring credit discounts in liability valuation leads in turn to the question of currencies and the meaning of risk-free valuation in an age of sovereign default. Finally, in the quest to resolve these puzzles, we shall examine recent work of Shaun Wang and of Dilip Madan and collaborators on the question of valuation in incomplete markets and estimate its virtues as a way forward toward achieving transparency in financial markets. We conclude with remarks on the role of financial regulation in applying these findings.

2. THE DUAL NATURE OF SECURITIES

Securities markets, like all others, are driven by the need of participants to equilibrate supply and demand. Demand is equal to the supply of investment capital—funds in excess of those needed for consumption by the owners. Supply is governed by the investment opportunities available. These opportunities, mostly the debt and equity of commercial companies, tend to be most productive and lucrative when funds available for consumption are widely distributed in the population (the "mass

market"). However, every participant in the economy has a limited appetite for consumption; any excess swells the supply of investment capital. Hence any imbalance in the distribution of wealth can depress the economic value of investments while at the same time stimulating demand for them, creating asset inflation. We have seen this phenomenon manifested in the technology boom of the 90s and in the real estate boom of the past decade, an era characterized by an abundance of investment capital and a relative dearth of investment opportunities.

Much has been said about derivatives and the dangers attendant thereto, but it is well to remember that every security or other financial instrument, in one sense or another, is a derivative. A policy of insurance is a derivative on losses from a specified event. A share of stock is a perpetual call on the net worth of a corporation and derives part of its value from the fact that, in case of liquidation, it expires worthless rather than becoming a liability. But such a share trades in the secondary market at a value which bears only an indirect, and sometimes very tenuous, relationship to the underlying value. The secondary market benefits the rest of the economy by providing an exit strategy for primary investors and price discovery for potential equity issues. Nominally the value of a share of stock should be given by the value of the future dividend stream adjusted for taxes and discounted at the default-free rate increased by the failure rate of the corporation and other vicissitudes. However, some of these quantities are hard to estimate and come with large uncertainties. But the shareholder has the option to hold and wait for the benefits of ownership to materialize or to sell to a willing buyer with a higher opinion of the share's value. The buyer may, in turn, buy in anticipation of holding or of selling to the next buyer. (By the same token, a deed of title to a house means one thing to someone who wants a place to live and quite another to someone who wants to sell to the next buyer who meets his terms, and may take on highly unstable values in a speculative environment.)

The point is that equity prices are governed by two competing dynamics: first, the underlying, "physical" value of the enterprise, which is determined by the conduct of the company itself and the markets in which it operates, can be estimated only with considerable uncertainty, and generates new information on a time scale roughly equivalent to the accounting cycle; second, market pressures and trading noise, which are usually driven by demand, particularly if a certain asset type is in vogue, and follow something like a random walk, on a time scale of minutes, with the peculiarity of reading tail events as signal and amplifying them. This disjunction between market price and underlying value means that equities can, and often do trade with only oblique reference to the underlying value of the enterprise. During the technology boom of the late 1990s, such proven value investors as

Warren Buffett stood by bemused as companies with no business plan or clear way to make money traded at astronomical prices because they had dot-com after their names.

Because of this duality and uncertainty, equity issues receive a great deal of attention from analysts and the investing public. Transaction prices are recorded and reported assiduously. In Professor Gorton's terminology, they are "information-sensitive" (Gorton, 2009b, p.4). A contrast is provided by high-grade corporate bonds, which are essentially loans with periodic interest payments (coupons). They can be valued with fair accuracy if one only knows prevailing market interest rates and the issuer's credit rating, provided by one or several of the recognized rating agencies. That is, they are derivatives on the lender's credit—its ability to fulfill its obligations. High-grade corporates, on Gorton's scale, are relatively "information-insensitive," default being perceived as a remote possibility, and trade, in the absence of adverse news, much like U. S. Treasury issues or currency, the most insensitive of asset classes. If a material credit downgrade occurs, and default becomes a clear and present possibility, the issue becomes more information-sensitive and trades at prices that reflect the price of the issuer's equity. At the high end of the scale, the most information-sensitive instruments are private contracts, such as policies of insurance, which are underwritten individually, apply to specific interests, and seldom trade, if ever.

In this connection, the MBS that caused the mischief are particularly interesting. The main purpose of pooling mortgages (and other assets) and slicing the pools into tranches is to produce securities of superior credit quality, AAA or near it, suitable for use as collateral in repurchase agreements and other banking (or "shadow" banking) transactions. Payouts to the junior tranches (of inferior credit quality) are governed by elaborate rules based on even more elaborate risk models, but are generally restricted to avoid paying out too early and shorting the senior trances. Nonetheless, if the assumptions governing the risk models turn out to be inadequate, the senior tranches may stand to lose out with more than the advertised probability.

Once the blessing of an AAA rating was conferred, little attention was paid by anyone as to the provenance of these securities or the assets that underlay them. In point of fact ABS were routinely passed through another level of pooling and slicing and dicing to produce collateralized debt obligations (CDOs) with putative properties better suited to the investor's needs, called such despite the fact that no one knew where to find the collateral. The prevailing assumption was that asset (house) prices would continue going up and that such knowledge would never be needed. To make matters worse, some CDOs were paired with liquidity puts to shorten maturity to one year, thus

meeting regulatory requirements for assets of money market funds. (You thought yours were safe.) (Gorton, 2008)

Thus the designer assets produced by structured finance spread throughout the financial system with almost no provision for tracking their whereabouts. For reliably tame, information-insensitive instruments, this dearth of information would be inconsequential. However subprime MBS had certain structural features which were very likely to lead to trouble if house prices ever stopped rising. This is because most of the underlying mortgages were adjustable rate (ARM), requiring the availability of financing when the mortgages reset (upward). When housing prices began to fall, collateral fell below the loan values; that financing dried up, leading to defaults. We shall discuss this in greater detail in later sections.

So far we have not mentioned commodity futures contracts. We shall do so in the next section in connection with the exchanges where they trade.

3. THE MARKETS IN QUESTION

The securities described in the previous section trade, if at all, in widely diverse markets.

3.1 Equities markets

Most equities are placed privately, or auctioned, at issue and subsequently trade on exchanges, which are highly structured, information-rich environments with self-imposed rules to ensure orderly trading. This secondary market serves the economic purpose of providing liquidity for primary investors looking for an exit and price discovery for prospective equity issues. In the United States, further regulatory discipline is imposed by the Securities and Exchange Commission (SEC) with restrictions on insider trading, attempts to corner markets, securities fraud, and other practices deemed prejudicial to the fair and orderly functioning of markets. Yet few would question that these are free markets in any practical sense, though they are not "free-for-all." They have a definite structure with mandated information flows, but they are structured to reduce the costs of vigilance and due diligence to manageable levels so that all participants have access to price information and all can buy and sell at the best available price. They also impose trading restrictions, such as maximum intraday price swings. The extremes of freedom, from which chaos and darkness are bred, have been sacrificed in the cause of efficiency.

It is usual for investors in equities to leverage their funds by maintaining margin accounts,

typically furnished by their stockbrokers at the going rate of interest and collateralized by the investors' equity holdings. This arrangement raises the possibility of a panic, which occurs when prices fall over a substantial sector of the market, reducing the value of collateral in the margin accounts and prompting margin calls from the brokers to cover the shortfall. Investors with insufficient funds to answer the call are forced to sell holdings into a falling market, driving prices down further, and initiating a vicious circle. Most stock market panics follow this pattern, including the great sell-off of 1929-1932. We shall see below that the Panic of 2007 was brought about by a similar mechanism, though not initially in the equities markets, but in the shadow banking system.

In *Foundations of Finance*, Eugene Fama (1976, Chapter 5, et seq.) defines an efficient market as one that fully reflects all available information. It seems, then, that the precondition of market efficiency—and the ability to judge whether a market is efficient—is the existence and ready availability of information. This is neither trivial nor obvious. Left to themselves, traders would rather play close to the vest and share knowledge with as few people as possible. Why do they forego the advantages of secrecy and submit to the discipline of the exchange? A likely answer is that the cost in time and money of obtaining information is prohibitive for an investor wishing to diversify her portfolio to attain an acceptable risk position. The business of obtaining information is best left to specialists, arbitrageurs, who profit from ignorance by dispelling it and discipline the market by occasional reference to fundamentals.

Fama analyzed daily and monthly stock returns on the New York Stock Exchange, testing for autocorrelation at various lags. He found no evidence for significant autocorrelation. This suggests that arbitrageurs filter information from trading noise on a time scale of a day or less. It says less about shifts in fundamentals. The equity exchanges adjust very quickly to breaking news. The real issue is how long it takes the news to break. How much information is encoded in accounting statements and other sources in forms that require elaborate processing to become news? To what extent can market efficiency be enhanced by improving the transparency of such information? We will explore this in a later section.

3.2 Fixed income

Treasury bonds are sold initially at public auctions then traded privately through private dealers. State, municipal, and corporate issues are sold at auction or through private placements then traded through dealers. There is very little exchange trading. The markets are over the counter because there are many fewer variables to be considered than in equities trading. The variables at question in

Treasury bond trading (and any trading in sovereign debt) are all public: fiscal policy and the inflation outlook for the relevant currency. For state, municipal, and corporate bonds, there is one additional variable that sums up all the residual risk: the creditworthiness of the borrower. This is investigated and made public by the recognized rating agencies, Standard and Poor's, Moody's, Fitch, and others.

Bond dealers employ specialists as market makers, who know the current market consensus as to the yield spreads above treasury associated with the various bond ratings (as well as, perhaps, some special knowledge as to the quality and currency of the ratings themselves). These market makers provide information to prospective buyers and liquidity for sellers for a fee embedded in the trading commission, as in equity trading. Information always comes at a cost, but so does ignorance.

Fama (1976, Ch. 6) framed the efficiency of bond markets in terms of ability to respond in timely fashion to expectations of inflation. Using data from Salomon Brothers rate sheets (no exchange to preserve data), he found that they did so reasonably well. Of course, the data period did not include the runaway inflation of the late 1970s and 1980s when bond yields fell below the rate of inflation for an extended period, the likely result of demand pressure from investors looking for investment vehicles to ease the effect of inflation. This reinforces our point that demand for the security itself, if strong enough can always swamp the fundamentals and drive up prices regardless.

3.3 Structured finance

As remarked earlier, structured finance products, such as MBS, CDOs, etc., are devised to resemble, as much as possible, treasury or corporate bonds except that there is little if any secondary market. What they do not and cannot provide are short and simple chains of accountability. Apart from demand considerations, if treasuries drop in value, it is because the Treasury and the Federal Reserve have mismanaged the money supply and brought about inflation—or the fear of it. If a corporate issue falls when the currency is stable, it is because the company itself has misbehaved itself in a way that casts doubt on its credit- worthiness; likewise for state and municipal issues. For structured finance products, the chain of accountability reaches back from retail financial intermediaries through the special purpose entities (SPEs) set up by shadow bankers to bundle and market CDOs, through MBS packagers such as Fannie Mae and Freddie Mac and still other shadow bankers, through the primary lenders, mortgage companies, to the mortgage brokers, mostly small operators who operated with minimal oversight and received their origination fees regardless of the quality of the loan.

The point of all this has been made persuasively already by Professor Gorton (2008): We have learned already that information comes at a cost. In the case of structured finance products, the cost of information is prohibitive. If something like the subprime defaults happens to cast doubt on the AAA (or whatever) credit rating, bestowed in the first place by a rating agency with questionable incentives, there is neither time nor money to sort out the composition of a structured product and to decide whether it is vulnerable to default and needs to be written down. There is no corporate treasurer to get on the telephone and demand the truth. If anyone knows the truth, he or she cannot be found. The only alternative is to panic. In a panic, doubt spreads rapidly because no one knows which structured products are tainted and which are clean. This is what happened, and ignorance has seldom come at a higher price. We shall see how this became a systemic event when we discuss the sale and repurchase (Repo) market.

3.4 Sale and repurchase (Repo)

Just as commercial banks finance their lending through demand deposits, shadow banks do so through short-term collateralized loans, known as "repos," because the borrower agrees to repurchase the collateral at a specified time, usually the next day. Securities received as collateral can be reused by the lender as collateral in other transactions, a practice known as rehypothecation. This has the effect of a dramatic increase in the money supply, as long as everyone believes in it, and of lengthening the chain of accountability if the positions need to be unwound. There is some ambiguity as to whether the repo transaction should be accounted for as a sale or a loan, which Lehman Brothers, in its death throes, used to move inconvenient items off of and onto its balance sheet at crucial times, e.g. quarter ends, in order to mask its true condition (Valukas 2010). But, in its normal usage, the repo market is entirely legitimate. It is, however, the darkest of dark markets. The shadow banking system has minimal regulatory oversight and no requirement to report detail on such borrowings; hence next to nothing is known about the size of the repo market. Professor Gorton (2008) estimates it as $10 trillion to $12 trillion at the height of the housing boom, though, in the absence of any clearing facility, this may include some double counting. We follow his very thorough exposition, touching on those of his points that illustrate our own.

Lenders in the repo market, as a rule, accept only very high-quality collateral. The speed and volume of transactions leave no time for research, so that only securities at the level of treasuries or AAA corporates are acceptable. The smooth functioning of the market is premised on the assumption that the credit ratings applicable to the offered collateral are accurate and reliable—in

Gorton's terms, on the assumption that securities used as collateral remain information-insensitive. This is Plan A; in the case of structured finance products, there is no Plan B for the reasons cited above.

As a system taking uninsured demand deposits is susceptible to panics, "runs on the bank," so is the shadow banking system if, for any reason, the offered collateral begins to lose credibility. When this happens, repo lenders begin to apply "haircuts," reducing the credited value of the collateral by some percentage. The application of a haircut is tantamount to a withdrawal from the shadow bank, reducing the amount of funds obtainable for a given amount of collateral. According to Gorton, the first signs of trouble in the repo market appeared in the ABX index, compiled from a thin sample of subprime MBS issues, which began trading in January 2006. Before this index began trading, there was no direct, publicly observable way for traders to put money on their estimates of the health of the subprime market. The ABX tracking subprime exposure began a steep decline in early 2007 (Gorton and Metrick, 2009). Since the structured finance securities used as collateral were packaged in such a way that it was difficult to tell how much they contained of the suspect subprime exposure, suspicion quickly spread to the entire class of structured finance products.

The haircuts applied to this class of collateral by the repo market are documented by Gorton and Metrick (2009). As of August 2007, the average haircut on structured debt was 0%. In succeeding months it rose at an accelerating pace, topping out near 47% at the end of 2008, by which time the repo market had shut down, strangled by a scarcity of collateral. Assets designed to be information-insensitive, in Gorton's terms, very swiftly became information-sensitive, urgently in need of scrutiny that was thwarted by that very design. This crippled the shadow banking system just as a run on demand deposits would cripple a conventional bank, were it not insured by the federal government.

As an immediate consequence the commercial paper market dried up, leaving a wide spectrum of businesses without short-term financing. In parallel developments, the defaults and foreclosures on subprime mortgages gutted the housing market and forced prices down even further. Widespread and severe unemployment led consumers to buy less stuff rather than taking on even more debt. Reduced public revenue and distress among other bond issuers led to cascading defaults and claims against credit default swaps (CDS), many of which had been written in the expectation of zero losses. Wall Street investment banks failed or came near it. Companies like AIG and Citicorp were saved only by massive infusions of federal cash. In the economy at large, the effective money supply was reduced drastically; and a deflationary spiral became a real and imminent danger, to be avoided,

in the absence of private funds, only at great public expense. As we have shown, the role of ignorance (lack of information) and its handmaiden, complexity (lack of transparency), in this debacle cannot be underestimated.

The ramifications of this opacity have continued to the autumn of 2010 in the form of a new crisis in the processing of mortgage foreclosures, which have proceeded in many cases with improper evidence, falsified affidavits, and inability to demonstrate ownership of the property being foreclosed. This has cast doubt on the provenance of all foreclosed properties and threatens to shut down the market in such properties, just as the subprime defaults shut down trading in a wide range of derivative securities. The crisis is far from over.

3.5 Futures Markets and Future Markets

Though the commodities markets played little or no role on the financial crisis, it is useful to describe their workings as an alternative to some of the opaque and disorganized operations of the OTC markets.

3.5.1 Conventional Exchanges

Organized futures exchanges have been in existence in one form or another for centuries. Modern examples emerged when transportation of agricultural products over long distances became possible by railroad. Contemporary exchanges handle trading in a wide range of agricultural, financial, and other products (though, in the U.S., not credit default swaps, by act of Congress, as noted above). All these products have the common feature that they are interchangeable, unbranded, and delivered in bulk.

The instruments traded on an exchange are derivatives: futures contracts that bind one party (short) to deliver and the counterparty (long) to take delivery of a stated quantity of goods of a given type and quality on an agreed future date at an agreed location. Contracts are standardized by quantity, date, and location to limit the number of distinct instruments being traded. Both long and short positions are traded freely up to just before the delivery date, subject to intraday price swing limits and position limits. At the end of each trading day, each trader is required to post margin to cover any imbalance in the account, a measure that eliminates counterparty risk. Trading is by open outcry—or its electronic equivalent—and all prices are known to all participants at all times.

There are two types of trader in the market: (1) those who own the underlying physicals or want to own them, and (2) those who wish to profit by speculation. The first type are managing risk by

hedging, locking in a price that they consider attractive. This can only be achieved if the market is efficient, that is if contract prices converge smoothly to the settlement values. This convergence is called price discovery. Some speculators trade actively and liquidate their positions in good time and are welcomed on the exchange for the liquidity they provide. A more recent arrival, the Long-Only Commodity Fund, as the name suggests, takes a large long position and holds it to expiration, rolling it over all at once. Though opinion is divided, many maintain that these operations impede price discovery, one of the most important informational functions of these markets, keeping prices high until just before settlement (CFTC Roundtable, 2008). They also have the potential that investor demand can drive up prices for the actual commodities. In any case vehicles like this are ill-suited to an exchange with frequent expirations and cause disruption of the market.

3.5.2 Innovation: Liquid Insurance Contracts

Commodity futures exchanges are among the most transparent of existing markets. A modification of this pattern is under development, proposed and patented by Oakley Van Slyke, FCAS (2007). This scheme was originally devised to trade insurance liabilities (Liquid Insurance Contracts). It has since been generalized to other instruments, but we confine our narrative to LICs for the sake of specificity.

Insurance companies that opt for this mode of operation will retain origination and underwriting functions, bundling policies of similar coverage, maturity, territorial, and underwriting quality characteristics into LICs for transfer to the LIC Exchange. Claims administration bodies, which may, but need not, coincide with the originating companies, will present claims against the bundled policies for payment by the Exchange.

Traders on the Exchange, called LIC Underwriters, or Transparent Traders, operate as corporations under the rules of the Exchange, with liabilities and assets fully disclosed on transparent balance sheets. Each is required to obtain, and maintain, a surety contract from a Surety approved by the exchange, who can maintain almost continuous audit of the Trader's condition. If the surety is withdrawn and cannot be restored, the Trader must dissolve and put its holdings to the Exchange for disposal. Provision and monitoring of surety makes position and price swing limits and margin calls unnecessary.

Traders bid on shares of LICs at prices based on past experience with LICs of similar characteristics. These shares can be traded freely based on information and opinion current among the traders. All trades are reported to the Exchange and to the Sureties so that there will be no

guessing as to obliged parties when claim payments come due and no uncertainty as to the composition of the traders' holdings. Traders can also adjust their risk characteristics by buying and selling assets and issuing equity.

Apart from obtaining participation of traders and companies, success of such a scheme depends on three major factors:

1. Recognition of the LIC transaction as a true liability transfer by regulators and accounting authorities so that companies are relieved of long term financial obligations. With such recognition, admittedly a major hurdle, policies bundled as LICs will not be carried as liabilities on the originators' books but will be reported as liabilities of the LIC Underwriters, and, indirectly, of the Exchange and its Sureties.
2. Recognition by primary markets of the superior security provided by the LIC Exchange and their willingness to pay for it.
3. Development of information systems capable of handling the large information flow reliably and efficiently.

This scheme exemplifies extreme trading transparency and promises to demonstrate its advantages if it can be realized. As the above description suggests, the scheme would be workable for liabilities or assets that lend themselves to standardization or both at once, as in a commodity or swap exchange.

4. ACCOUNTING AND FINANCIAL MARKETS

Corporate financial statements have traditionally been only a subset, albeit an important one, of the information considered in deciding how much to pay for a share of stock or a bond. Equity value investors look at the balance sheet and add their own fact-based estimate of the franchise value of the firm to decide whether current prices are attractive. Other investors look at the history of stock price movements for clues as to the future movement of prices. As we have argued, whether accounting fundamentals or noise trajectories dominate the trading, depends in large part on the quality and credibility of the accounting information. Outside the equities markets, as we have seen, bond prices of firms with inferior credit tend to follow their stock prices.

Prior to the advent of fair value in the late 1990s, the flow of information was essentially one way from the financial accounting system to the financial markets. Financial instruments were put on the

balance sheet at purchase price or cash received and held there or amortized to maturity at a fixed rate. Valuation was not a basic accounting practice. Balance sheet values were rolled up from transaction cash flows by a process called deferral and matching. The values on the books need have little to do with changes in the financial markets, and large adjustments might be required when disposing of assets or acquiring resources to fulfill liabilities. (Exceptions were made for some major items, such as casualty insurance loss reserves, which typically have changed to reflect the latest information.)

4.1 Information flow under fair value

With fair value, information flow has changed radically, effectively turning the discipline of accountancy on its head. Valuations are to be kept up-to-date, reflecting the current state of the markets; and internal value flows are driven by changes in valuation. Where markets exist, assets are to be marked to their current market value. Liabilities are to be marked to the price at which they could be extinguished by repurchase, that is, at the value the creditor places on them as assets. Where no markets exist, values are to emulate market prices as closely as possible. A moment's thought tells us that assets, valued for immediate redemption, less liabilities, valued at the repurchase price, is precisely the market value of a firm in liquidation. Reflecting further, one can see that a credit downgrade will cause the market value of a firm's liabilities to decrease, creating a windfall and a surge in earnings. This is not a mere curiosity, but has already happened. In first quarter 2008, Radian Group's credit was downgraded, leading to a $410,000,000 windfall on revaluation of its liabilities. Radian apologized in its published financials, explaining that it only followed established accounting guidance. In first quarter 2009, Citigroup took a downgrade that led to a $2.5 billion (!) windfall. Rather than apologize, Citigroup bragged about its earnings and started laying plans for bonuses and TARP paybacks. Other major firms experiencing this sort of oddity include Bank of America, Lehman Brothers (now defunct), and Morgan Stanley. Few laymen have as pretty a taste for paradox as do seasoned professionals, and most would agree that this is mere nonsense. One often hears the argument that everyone knows that such results are bogus and discards them—and replaces them with what? Information vacuums do not persist but are filled with bad information when good information is not available. The problem must be fixed. IASB has attempted to address the outcry with mixed results, as we shall discuss below.

The inconsistencies inherent in the current approach to fair value are apparent in an example cited in Crooch and Upton (2001), which we quote here:

Company A issues a pure-discount (zero-coupon), nonprepayable, 10-year $10,000 note to a lender. Consistent with Company A's AA-rated credit standing, the note is discounted at a 7% annual rate and Company A receives $5,083 in cash. Under today's GAAP, Company A records a liability of $5,083.

On the same day, Company B issues a pure-discount, nonprepayable, 10-year $10,000 note. Consistent with Company B's B-rated credit standing, the note is discounted at a 12% annual rate and Company B receives $3,220 in cash. Under today's GAAP, Company B records a liability of $3,220.

On the same day, the rate appropriate to comparable U.S. Treasury instruments is 5.8%.

These postings are consistent with both traditional GAAP and proposed fair value. We see immediately, and by design, that two companies enjoying the status of going concern, but having somewhat different credit standing, can undertake identical obligations and record materially different liabilities for them. Figure 1 depicts how these obligations, in comparison with a risk-free obligation, amortize to maturity in the absence of any change in the risk-free rate, market credit spreads, and credit standing.

Figure 1. Current GAAP: Good, Bad, Riskless

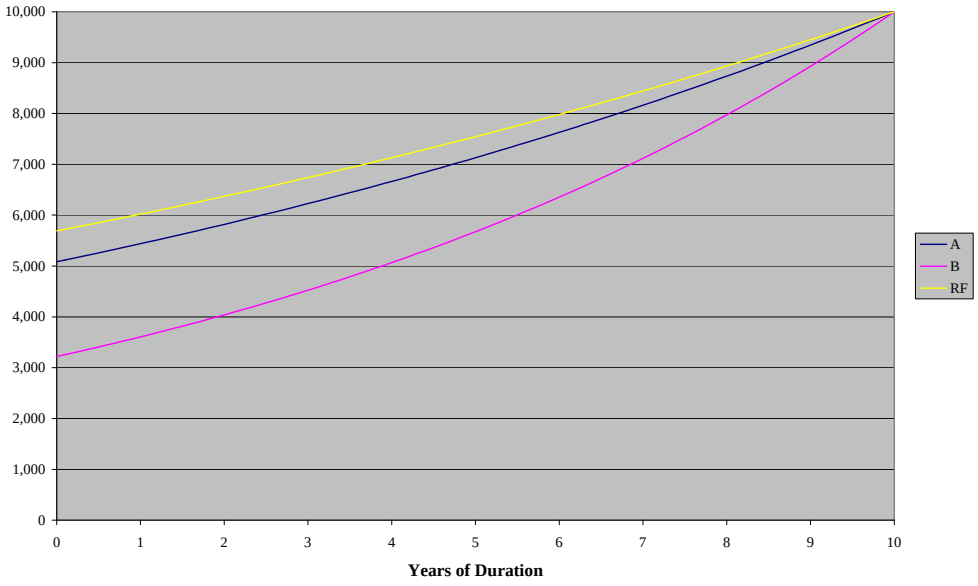
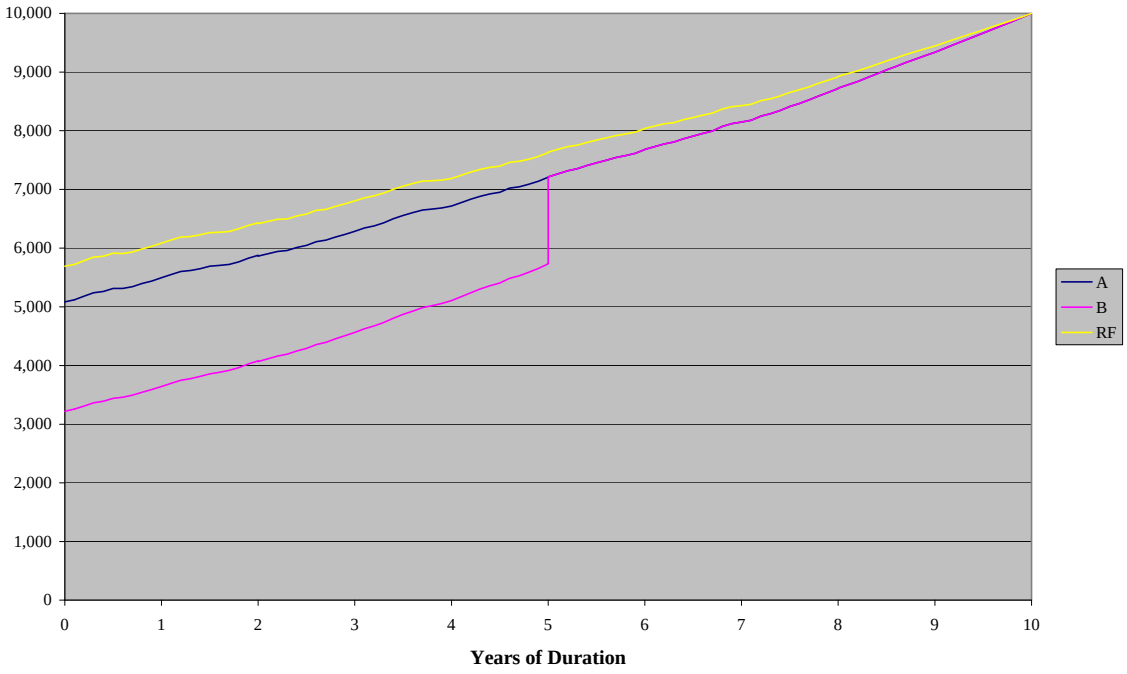


Figure 2 shows the effect, under fair value, other things being equal, of an upgrade in credit of Company B to AA five years into the term of the loans. This causes the value of the liability to *increase*, simultaneously causing a *loss* to appear in income.

If Company A were to suffer a rating downgrade to B, it would *decrease* the liability by this same

amount and would enjoy a windfall *profit* in the same amount. This would be impossible to justify were it not for the fact that no one has ever voiced any objection to the traditional treatment at first recognition. In some cases, tradition means not having to care about common sense.

Figure 2. FASB Fair Value: B improves after 5 years



The standard-setters firmly maintain that the standards they propose are intended to be appropriate for going concerns; firms at the other end of the solvency spectrum from firms in liquidation (with various states of bankruptcy in between), that are expected to remain in business for the indefinite future. A question we must ask is whether standards we have shown to be suitable for firms in liquidation could also be suitable for going concerns. In my view, the answer is clearly **no**. Going concerns differ on two vital points, following from their definition:

1. A going concern is generally in no hurry to redeem its assets for cash. Any liquidity penalties embedded in asset prices should be restored in the valuations, excepting assets needed for ready cash.
2. A firm holding itself out as a going concern is expected to perform its liabilities as specified in the contract. The repurchase price is irrelevant. The value of a liability should

depend only on the terms of the contract and the cost of fulfilling it as written. Firms holding similar liabilities should record similar values just as if they were sovereign obligations. This implies that the credit discount implicit in the price of a liability held as an asset (actually the combined effect of own credit standing and liquidity) should be added back to the liability value of a going concern.

The liability issue is addressed in Heckman (2004). A useful review of the role of liquidity in asset pricing is given in Amihud et al. (2005).

Enforcing requirement #2 introduces two puzzles used as objections on the other side of the debate. Both have to do with the difference between the full funding amount and the cash proceeds. We can call this amount the "borrowing penalty" since it contains elements of both credit risk and liquidity risk.

1. Booking the full funding amount implies taking a loss at inception equal in amount to the borrowing penalty.
2. At any time after inception, the firm can go into the market and realize a gain by repurchasing its own liability.

It is clear that these are both part of the same puzzle, hinging on the treatment of value flows; and both were solved at one stroke in a paper by Chasteen and Ransom (2007). They propose that:

1. The full funding amount should be booked as the liability at inception. The cash proceeds (asset value) should flow to income; the borrowing penalty should be charged directly against equity.
2. On update, changes in the full funding value should flow to income. Any gains on repurchase due to changes in own credit should flow directly to equity.

Since the borrowing penalty is made up directly from equity, without passing through income, there is no loss at inception; and all calculations of income reflect management actions and not decisions affecting credit standing, which are the domain of the owners. If the company, for whatever reason, should decide to repurchase the liability at a discount in the open market, any gain would flow directly to equity, without passing through income.

We feel strongly that fair value in its present form does little to promote transparency in financial reporting, and that the reforms proposed and described here would go far toward restoring that mission.

Even though fair value, as proposed, is beset by puzzles and anomalies, and does not even produce the information needed to support the decision as to whether or not an enterprise is a going concern, the central idea of introducing market discipline into accounting valuation is a worthwhile one. Another way of viewing these puzzles is to recognize that fair value, intended to describe the financial condition of a going concern, prescribes marking to the wrong markets.

We have seen that a going concern is not constrained to accept the spot price when redeeming its assets for cash. Liquidity crises, like the recent catastrophic one, are the exception rather than the rule; but, when they occur, the value of a firm's option to defer asset sales can be substantial. Amihud et al. (2009), in reviewing data and analytical work on liquidity effects in asset pricing, have found evidence that both the level and the risk of liquidity are priced in the market. Whether such pricing of an episodic effect, perhaps through options and futures markets, is robust and pervasive enough to support mark-to-market accounting is a question that requires investigation. A positive answer would suggest that any identifiable and quantifiable liquidity penalty should be added back to the asset valuations of a going concern.

We also understand that repurchase of a liability in the open market is not something that going concerns do. The Chasteen and Ransom proposal makes clear that such an action amounts to withdrawing capital from support of the enterprise and winding down business. An asset repurchase imposes both liquidity and credit penalties on the counterparty because such a transaction is typically a take-it-or-lose-it proposition. Such penalties do not apply when a company is holding itself out as a going concern undertaking to fulfill its contracts in full and on time. Restoring the liquidity penalty, if any, still leaves the credit penalty—the cost of surety. It is worth noting that reliable surety is precisely what is required for liabilities to trade freely: to close the gap between the value to the creditor and the cost to the debtor—between bid and ask. A rational third party will not assume a liability unless the cost of surety is included in the price. So the critical market to consider when pricing the liabilities of a going concern is the surety market, supposing that it exists. Marking to the spot asset price of the obligation is very questionable, as it leads to such anomalies as gains on credit downgrades and losses on upgrades. In addition, it leaves liabilities underfunded, makes effective capital management more difficult, obscures the costs associated with inferior credit, and disposes management to take risks that they might not if their true capital position were known, e.g. issuing junk bonds instead of equity. There remains the familiar objection that a debt issuer can realize a gain after a credit downgrade by repurchasing its debt in the open market. I suggest that any such gain should be accounted for as a windfall and that, following Chasteen and Ransom (2007), the gain

should flow not through income but direct to equity.

Just as important, marking assets and liabilities to the wrong markets sends false signals back to the capital markets, amplifying volatility and portraying debt financing in a falsely advantageous light. This latter quirk, for instance, places property-casualty companies at a chronic disadvantage in the capital markets vis-à-vis the nonfiduciary companies that rely more heavily on debt financing. Arguably, this persistent inequity has spawned really perverse reinsurance deals that have put some very unlikely people in orange jumpsuits.

4.2 Open issues

Implementing the Chasteen and Ransom program for liabilities is straightforward when accounting for debt issues, where the amounts and timings are specified by contract and the only risks, apart from inflation, are those of credit and liquidity. None of these risks affect the calculation of the full-funding amount since inflation and other currency risk are embedded in the default-free rates. For other types of liability, such as a policy of insurance, payouts can be wildly uncertain, and one must consider the issue of risk premiums. This is not a problem we shall solve here, but only call attention to it as a very knotty one. In commercial casualty insurance, for instance, liability risk premiums vary widely according to market conditions, routinely taking on negative values near the trough of the underwriting cycle and consuming surplus that would have performed better in treasuries. How to deal with this variability in an accounting context is an open question.

Another open question is the going concern valuation of assets. This involves disentangling the credit penalty from the liquidity penalty and quantifying the latter, which is variable—almost evanescent. Some work (Amihud et al., 2009) has been done on the subject, but more is needed.

A novel scheme for estimating liabilities has been proposed by Dilip Madan and coworkers (2009). Using coherent risk measures (Artzner et al., 1999) and convex probability distortions (e.g. Wang, 2000), they define an index of acceptability applying to a given transaction, characterized by the probability distribution of the cash flows. Applying this formalism to incomplete markets, they identify bid and ask prices for a given financial obligation. In an incomplete market, the actual transaction, if it takes place, does so at an indeterminate value between bid and ask. Madan proposes posting the asking price as the liability and the bid price as the countervailing asset, with the differences held in reserve against deterioration in the position. This is a promising line of research with the potential of providing a complete theory of liability and asset valuation.

The reader will have perceived that these problems are some distance from resolution. We must agree with the standard-setting bodies that the goal of market discipline in accounting valuation is an important one. However, the present haste is likely to be counterproductive, particularly if there is uncertainty as to which markets should provide the discipline.

5. CONCLUSION: IMPLICATIONS FOR REGULATION

I hope that the foregoing has made the case that future changes in financial regulation should focus on information and disclosure. Much of the mischief that brought about the crisis of 2007 could have been avoided had reliable information on structured securities and derivatives been available. Professor Gorton, who put together such a convincing narrative of the collapse of the shadow banking system, was hobbled in his modeling efforts by lack of information on the subprime content of the CDOs on which AIG was writing CDS. If these securities and derivatives were traded on well-structured exchanges like shares of stock, instead of over the counter like bubble gum, provenance would have been documented, counterparties could have been identified, and contrary positions could have been netted out in a clearinghouse. None of these functions were carried out in the frenzy that led to the crisis.

Many of these defects can be remedied without the most meddlesome aspects of regulation. The power of law can be used to establish structures wherein necessary disclosures are a condition of membership and to place outside the law and to declare unenforceable contracts entered into outside the structure. Contracts that cannot be enforced in a court of law will seldom be entered into. Where orderly structures and procedures are in place, people tend to use them just as someone concerned with getting from A to B will follow established routes rather than building new roads. We have described structures that can be used for trading exotic securities and derivatives: existing commodity futures exchanges or the LIC scheme proposed by Van Slyke, for instance.

Even the problem known as "too big to fail," the difficulty of unwinding the affairs of systemically important institutions, has more to do with information and transparency than with mere size. Were it not for the extreme interconnectedness of major financial institutions, size would hardly matter at all. The failure of Lehman Brothers brought about the near collapse of the financial system and a total freeze on credit not because of Lehman's size as such, but because of the myriad of counterparty relationships in which it was involved, threatening a cascade of failures throughout the system. Many financial instruments are traded hand-to-hand, like the family fruitcake, with no

record beyond one step afield of where they have ended up. The complexity and opacity of this contractual web could be reduced enormously by trading on exchanges with their clearinghouse function. If this were to become prevalent, no institution would be "too big to fail." It is not size itself that is prohibitive, but the information cost of tracking down counterparties and winding up affairs—the cost of complexity and opacity.

Other causes have been cited for the recent financial meltdown. One is the human capacity for self deception; another is the prevalence of perverse incentives in the financial industry. These are undoubtedly important factors, but I suggest that they tend to flourish in an atmosphere of doubt, ignorance, and defective information. Good information, readily available and impossible to ignore, will reduce opportunities for self deception and expose the defects of perverse incentive plans. Better information is not so much a sovereign remedy as a condition sine qua non.

Apart from some ill-advised asset holdings and the vagaries of corporate parents, the insurance industry was in large part insulated from the frenzy on Wall Street. It would be wise to keep it that way until adequate reforms are enacted.

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Abbreviations and notations

ABX, subprime MBS index
AIG, American International Group
ARM, adjustable rate mortgage
CDO, collateralized debt obligation
CDS, credit default swap
CFMA, Commodity Futures Modernization Act
CFTC, Commodity Futures Trading Commission
GAAP, generally accepted accounting principles
IASB, International Accounting Standards Board
LIC, liquid insurance contract
MBS, mortgage-backed securities
OTC, over the counter
SEC, Securities and Exchange Commission
TARP, Troubled Assets Relief Program

Biography of the Author

Philip E. Heckman holds a B.S. in Physics and Mathematics from Purdue University and a doctorate in Physics from the University of Chicago. He joined the insurance industry in 1975, working as a casualty actuary and statistical analyst, later in audit support and actuarial consulting. He is an Associate of the Casualty Actuarial Society and a member of the American Academy of Actuaries. He is active on the CAS Committee on Theory of Risk and the *Variance* Editorial Board, and on the CAS Accounting Changes Task Force. He also sits on the AAA Financial Reporting Committee and the Halmstad Prize Committee.

Phil's interest in accounting and related financial matters began with the advent of fair value, from observing the perverse consequences of marking liabilities to market. He has published several pieces and delivered several talks challenging the assumptions and conclusions of the standard-setting bodies, most recently accentuating the contrast between liquidation and going-concern accounting and the modifications needed to put fair value on a going concern basis.

Practical Considerations in Assessing the Impact of Inflation on Carried Reserves

Michelle Morrow, FCAS, MAAA, and Timothy Conrad, FCAS

Abstract: As the U.S. economy recovers from its most recent financial crisis, concerns are rising that inflation could increase dramatically in the near term. This paper attempts to quantify the effects that accelerated inflation could have on a company's balance sheet using the methodology proposed by Mr. William Richards in his 1981 paper titled, "Evaluating the Impact of Inflation on Loss Reserves." Data were evaluated regarding the appropriate loss components to use for modeling (loss, salvage/subrogation recoveries, loss adjustment expense) and the identification of appropriate indices in conjunction with the timing of the inflationary impact. In addition to testing several of Richards' key assumptions, the methodology is utilized in a slightly different fashion than originally proposed. Instead of using a single index to deflate historical losses, a selection of reasonable indices was implemented so that a range of expected outcomes could be evaluated for each level of assumed future inflation.

Keywords: Discounting of Reserves, Exploratory Data Analysis. Inflation, Reserving Methods, Reserve Variability.

1. INTRODUCTION

Once again the P/C insurance industry has cycled back to asking questions about the impact of inflation on carried reserves, given current economic circumstances and the not-too-unreasonable expectation that the industry could soon enter a period of aggravated inflation. In 1981, Mr. William F. Richards published an approach to quantifying this effect titled, "Evaluating the Impact of Inflation on Loss Reserves"[1]. Mr. Richard Woll contributed a review of his publication [2], raising three concerns with Richards' process. Woll states that the primary issue is different types of losses inflating at different rates do not necessarily settle at the same rate. The second concern was that Richards' approach assumes that all losses are affected by inflation until paid. Woll instead suggested the derivation of a matrix representing the degree to which losses paid in a particular year of development are affected by inflation subsequent to the year of occurrence. Finally, Woll raised concerns over the application of Richards' method to incurred loss triangles due to complications in adjusting case reserves for inflation and the need to forecast future payment and reserve patterns.

This paper will attempt to address and test several of the stated assumptions in using Richards' methodology, provide practical examples of its application, and address Woll's concerns. Data from a large P&C company was utilized by (approximate) Schedule P lines of business. Although the obvious focus is on those segments which have a longer "tail" and are therefore susceptible to inflationary impacts, all lines are included in the appendices for completeness and reasonability

testing. The first goal was to estimate the possible effects of major inflationary shifts on corporate P/C reserve balances with special focus on personal and commercial auto liability (which together comprise 57% of direct reserves). A second and related goal was to identify which indices best predict inflationary impacts on reserves so that the company's investment division could simultaneously model inflation scenarios against the asset and liability portions of the balance sheet.

2. DATA CONSIDERATIONS

The first step in Richards' methodology was to establish a profile of loss costs by component (medical, wage, legal fees, pain and suffering, etc.). Our approach looked at multiple snapshots of data, depending on the line of business.

- Homeowners/Farmowners—Liability, property non-storm, storms, all combined property.
- Auto liability—Personal versus commercial business separately and combined (Parts B and C of Schedule P). Property damage liability was also evaluated separately.
- Workers Compensation—Medical versus indemnity and combined.
- Commercial Multi-Peril - Liability, property non-storm, storms, all combined property.
- Other Liability—In total.
- Special Property—In total.
- Auto Physical Damage—Personal versus commercial business, separately and combined; storm versus non-storm and combined.
- Other—In total (this includes a small book of individual health products).

All analyses were conducted direct of reinsurance. Individual loss components were studied as well:

- Gross loss paid
- Salvage/subrogation received
- Net loss paid
- D&CC (Defense & Cost Containment) expense paid
- Gross loss/D&CC paid
- Net loss/D&CC paid

3. EVALUATING THE TIME ELEMENT

Richards' next step was to identify those economic indices which best measure the inflation in loss costs and the timing of the inflationary impact. The first issue addressed was the timing of the impact of the inflationary effect. We organized losses by accident year, report year, and closed year, then considered total claims (with case reserves as of 12/2009) and closed claims in calculating severities. Each evaluation included data from 1995-2008, where an ordinary linear regression on claim severity was fit against a plethora of individual economic indices. For the report-year and closed-year analyses, the oldest accident year included was 1990. Included in Exhibit 1 below are the resulting coefficients of determination for this evaluation against the average annual Consumer Price Index (CPI), sorted in decreasing order by reserve volume and increasing predictability for Auto Liability:

Exhibit 1
Measuring Goodness-of-Fit by Time Period

Segment	Percentage of 12/2009 Reserves	Closed Claims by Accident Year	All Claims by Accident Year	All Claims by Report Year	Closed Claims by Report Year	Closed Claims by Closed Year
Auto Liability	57%	1%	38%	42%	67%	70%
Commercial Liability	19%	55%	20%	63%	31%	98%
Fire Lines Property	9%	90%	95%	95%	4%	98%
Fire Lines Liability	4%	16%	58%	66%	22%	95%
Work Comp Medical	3%	18%	83%	84%	10%	96%
Commercial Property	3%	89%	93%	92%	3%	93%
Work Comp Indemnity	3%	50%	46%	53%	20%	96%
Auto Physical Damage	1%	96%	97%	96%	64%	91%
Health	1%	79%	87%	92%	75%	92%
All Lines	100%					

It was observed that the most predictive relationship between claim severity and economic index was found when evaluating closed claim severity by closed date. Surprisingly, this was true across most lines of business, the only exception being Auto Physical Damage. Workers Compensation–Indemnity (WCI), for example, intuitively should track better with the date of accident, yet the historical data did not bear this out. Even including the current case reserves did not significantly improve predictability for WCI on an accident year basis. To test the sensitivity of our analysis, we also repeated the analysis by varying the number of years included. This did not significantly affect the outcomes.

One of Woll's concerns is that not all losses may be inflation-sensitive through the paid date. Our finding that severity tracks best with the CPI (and other indices) when organized by closed year

suggests that the closed date assumption may in fact be most appropriate for the dataset analyzed. Since the best "fit" of economic inflation versus severity is found by closing (as a proxy for paid) date rather than accident or report date, this concern was laid to rest as regards our data. Though it is possible that some losses indeed are not inflation-sensitive beyond the accident date, these losses are not prominent in the observed data, either due to a relatively smaller volume of these types of losses, or perhaps that these losses tend to be closed very soon after the accident date—in either case, any "misclassification" on our part of these losses as being inflation-sensitive through the closing date will likely have little impact on reserve volatility due to inflation. All subsequent analyses on the relationship between severity and economic indices were completed on a closed claim by closed year basis. It may be helpful to note that we considered an additional evaluation of severity by paid date, but complications with claim counts on claims with payments spanning multiple years made this impractical.

4. IDENTIFYING THE "BEST" ECONOMIC INDICATORS

To next quantify which indices best measure the inflation in loss costs, Appendix 1 shows the R-squared values for claim severity and loss costs regressed against various publicly available economic indices, on an annual average basis where available. Where two values are shown for a given cell, there was statistically significant autocorrelation present in the data (the second number is the R-squared of the auto-regressed data). These results were derived using a univariate Regression Analysis with Autoregressive Errors procedure in SAS. The first observation is that the predictive relationship between claim severity and index appeared stronger than was true for loss cost and the same index. This makes intuitive sense as the commingling of frequency trends with severity trends can produce a dampening effect on loss costs. The notable exception is for Auto Liability, where the loss cost analysis produced a similar fit as was true for severity.

A review of these R-squared values for severity by line of business versus the assorted indices showed high predictive power, commonly above 80%. While this suggests strong relationships, a reasonably high R-squared value is to be expected for any increasing series of data. We would generally expect severity to increase at a stable rate over time. If we expect this severity increase to be approximately linear, then any other linear trend should regress fairly well against this data (the index in this case would serve as a proxy for time). Exhibit 2 demonstrates this concept.

Exhibit 2
Increasing Time Series Example

Closed Year	Auto Liability Paid Severity	Index		
		CPI	Linear1	Linear2
1990	1,386	130.7	1	1
1991	2,068	136.2	2	3
1992	2,643	140.3	3	5
1993	2,837	144.5	4	7
1994	2,873	148.2	5	9
1995	3,060	152.4	6	11
1996	3,020	156.9	7	13
1997	3,441	160.5	8	15
1998	3,615	163.0	9	17
1999	3,672	166.6	10	19
2000	3,730	172.2	11	21
2001	3,852	177.1	12	23
2002	4,078	179.9	13	25
2003	4,248	184.0	14	27
2004	3,885	188.9	15	29
2005	3,900	195.3	16	31
2006	4,000	201.6	17	33
2007	4,074	207.3	18	35
2008	4,190	215.3	19	37
2009	4,190	214.5	20	39
	Correlation	83.8%	87.6%	87.6%
	R-Sq	70.1%	76.7%	76.7%
	Slope of regression	15.4	75.1	37.6

This does not mean there is no predictive power in our indices, only that the relative predictive power is somewhat clouded in this statistic by the expected increasing trend. We expect severity to rise on average, and so we should expect a high R-squared for any increasing index. However, we should also find additional predictive power (i.e., relatively higher R-squared) from indices whose overall increasing trend fluctuates more closely with varying levels of inflation.

To further refine the list of indices to use in subsequent analysis, we next evaluated the percentage change in severity versus the percent changes in the various inflationary indices. Fit statistics for this data are not impacted by relationships of the index through time—that is, we will not find more predictive power simply because an index is higher in 2009 than it was in 2000, as we would expect to find using the raw index vs. raw severity. In Appendix 2, predictive power is measured by the linear correlation between the change in severity and the change in a given index during the same period. As expected, correlations were found to be lower using change in indices as

compared to the raw index, but appear to generate additional insight into which indices might be best to use in Mr. Richards' methodology. Based on the range of resulting correlations, we judgmentally termed any correlation above 30% as "moderate," and above 50% as "strong." As was true for the initial regressions on severity versus index value, please note that some of the lines showed moderate to strong correlations with counterintuitive indices (e.g., Auto Physical Damage with CPI Housing). Some observations on the data for longer-tailed business:

1. Commercial Liability exhibits strong correlations with CPI Medical Services and CPI Total Medical Care.
2. Fire Liability exhibits very strong correlations with CPI Medical Services and CPI Total Medical Care indices.
3. Workers Comp showed moderate correlations with the CPI Less Food index.
4. No reasonable relationships were seen in Long Tail Auto or Other Liability.

In hopes of further reducing the volatility in our severity data, we also explored the linear correlations of three-year-moving-average changes in severity vs. three-year-moving-average in index changes, as shown in the bottom section of Appendix 2. To accomplish this, we first calculated the year over year changes in these figures, and then took three-year-moving averages of the changes. Many lines showed improved correlations with the various indices, though some of these indices had counterintuitive relationships with the line of business. The process was repeated for loss cost correlations as shown in Appendix 3. Three long-tail lines had notable changes:

1. Commercial Liability and Auto Liability loss cost correlations improved for CPI Total Medical Care and CPI Medical Services. This improvement was not evident in the severity analyses.
2. Workers Comp loss cost correlations increased dramatically for total CPI and the CPI Medical Indices. This was not observed among the severities.

Most disconcerting was the observation that Auto Liability correlations did not emerge as significant in any snapshot of the data and seemed to behave differently from other lines of business. It is possible that we still have not yet solved for the most appropriate data presentation. One theory is that we might need to break out the data on a coverage and/or state level for better results. Nonetheless, faced with no clear choice of economic index we took a step back to review the entire purpose of the exercise.

5. CIRCLING BACK

The goal of this project was to understand the potential impact of changes to inflation on needed reserves. Although several published economic indices appear to track well with average severity, none can be clearly seen as demonstrating a strong cause/effect relationship as we might have hoped. We therefore asked ourselves again the question of what we are trying to accomplish.

The overall result from these analyses suggests that each index likely explains some base level of pure inflation in the severity, but may not fully explain the change in severity over time. This makes intuitive sense in that claim severity is subject to random fluctuation, coverage enhancements, changes in the tort environment, etc.—all items that can be independent of pure inflation, but often serve to affect severity over time. Richards assumes that data which has been appropriately adjusted for inflation will show neither an increasing nor decreasing trend in the loss costs. We assert that given the reality and nuances of competing forces operating in what is paid to claimants over time, simply correcting for inflation should not eliminate *all* of the trend seen in the severities and loss cost. In fact, the construction of the CPI explicitly attempts to remove the impact of price changes due to changes in the quality of goods over time. Any deflation based solely on CPI-type indices should be expected to leave behind "quality trends" in the deflated data—these trends reflect real, non-inflationary cost changes to the insurance industry. One example of this phenomenon has been shown for auto physical damage: with the advent of airbags in new cars, the average severity increases because the replacement of the airbag necessitates the replacement of the entire dashboard. Greater safety for the passengers (possibly decreasing BI and Med Pay severities) comes at the cost of higher physical damage severity. A second example, also affecting auto physical damage, is the recent industry trend toward higher deductibles which generates higher claims severity as well.

We therefore believe a practical (and even more useful) application of Richards' methodology would be to deflate the paid triangles using a selection of indices with good "fits" and evaluate the range of expected reserves needed under different inflation assumptions. In this endeavor, special attention should be given to those indices which exhibit higher R-squared on the raw data, show moderate to strong correlations for the change in values over time and make intuitive "sense." Net paid losses (plus D&CC expense) were analyzed using Richards' Paid Loss Deflation methodology for 19 indices which attempt to quantify inflationary pressures. Indices can be grouped into two major categories according to whether they are specifically designed to calculate inflation (CPI measures, Houses Sold PI, Fisher and GDP indices, Unskilled wage) or other potential "indicators" of price changes over time (stock market indices, Gold Price, Oil Price). As would be expected, the first category of indices produces more intuitive results. The results of this study are contained in Appendix 4.

6. DEFLATING PAID VERSUS INCURRED TRIANGLES

For long tail lines of business, where paid loss development is of limited use in early years, Richards presents a similar method for deflating incurred loss triangles. For this method paid losses and case reserve are deflated separately—losses deflated from the date paid, and case reserves from the date outstanding. Woll brings up two complications with this method—(1) case reserves are estimates of payments to be made at a variety of future dates and may include expectations of future inflation, and (2) the method requires forecasts of paid losses and case reserves to properly re-inflate the incurred losses after development.

Depending on how case reserves are established, Woll's first concern is not an issue. Consider two extremes: (A) case reserves are established in today's dollars, and so represent a present value of future payments, and (B) case reserves represent the nominal or full value amount to be paid in a future period. In (A), applying a single deflation factor from the date the reserve is held is appropriate—the lag time to when the reserve is ultimately paid is irrelevant since it is held at its present value. In (B), Woll's concern is valid, but adjustments can be made to first bring the case reserves to a present value basis, and then a deflation factor can be appropriately applied as prescribed by Richards. We will address this process next.

Discounting case reserves requires the assumed future inflation rate and expected payment patterns. For simplicity, we assume that expected future inflation can be determined by a 10-year exponential trend on the CPI, or about 3% in this case. For payment patterns we will use those implied by the standard paid loss triangles and resulting ultimate loss estimates. Case reserves likely have faster payout patterns since they are not elongated by losses yet to be reported, but we continued with our simplified assumptions.

A case reserve discount factor can then be calculated for each accident year, at each evaluation period as the weighted average discount factor for all prospective payments, with weights equal to the portion paid at each prospective maturity. For example, the following exhibit comes from the Auto Liability paid loss triangle, with an exponential trend used to determine LDFs for years 10-15:

Exhibit 3
Case Reserve Discount Factors for Auto Liability

	(1)	(2)	(3)	(4)	(5)	(6)
Maturity	LDF	CDF	Remaining % Unpaid	Incremental % Paid	Prospective % Paid	Case Discount Factor
12	1.674	2.460	59.35%	40.65%	100.00%	0.938
24	1.202	1.470	31.96%	27.39%	59.35%	0.937
36	1.104	1.223	18.24%	13.72%	31.96%	0.938
48	1.054	1.108	9.78%	8.46%	18.24%	0.938
60	1.024	1.052	4.91%	4.87%	9.78%	0.932
72	1.009	1.027	2.59%	2.32%	4.91%	0.924
84	1.006	1.017	1.67%	0.91%	2.59%	0.925
96	1.003	1.011	1.04%	0.63%	1.67%	0.925
108	1.002	1.007	0.71%	0.33%	1.04%	0.931
120	1.002	1.005	0.48%	0.24%	0.71%	0.938
132	1.001	1.003	0.28%	0.20%	0.48%	0.943
144	1.001	1.002	0.16%	0.12%	0.28%	0.950
156	1.001	1.001	0.09%	0.08%	0.16%	0.960
168	1.000	1.000	0.03%	0.05%	0.09%	0.971
180	1.000	1.000	0.00%	0.03%	0.03%	1.000

Assumed Inflation	3%
(7) One Period Discount Factor	0.971

The Remaining % Unpaid in (3) is equal to [(1)-1/(2)]. The Incremental % Paid in (4) is the change in (3) from the earlier maturity to the current maturity. The Prospective % Paid is an upward sum of (4). The Case Reserve Discount Factors for each maturity are then calculated using the subsequent maturity values [(6 * (5) * (7) + (4)*(7)]/(5). Multiplying these factors by the case reserves held at the corresponding evaluation date will bring full value case reserves to the present value at that date, which can then be deflated in the same manner as paid losses.

Woll's second concern is that Richards' formulas require accurate paid loss and reserve forecasts. These are easily derived from the standard paid and incurred loss triangles by selecting paid loss to incurred loss ratios from the history. For our data, these ratios were quite stable, and could be projected into the tail using various methods.

Using Richards' formula for incurred loss triangles, we tested the two case reserve scenarios mentioned above (set at full value, and set at present value) on Auto Liability and Workers Compensation. Two interesting discoveries emerged:

- With reasonable LDF selections both case reserve scenarios produced essentially the same unpaid loss estimates.

- Both scenarios had the same sensitivity to changes in inflation, which was the same as the inflation sensitivity to the deflated paid loss method (see below).

Exhibit 4

Comparison of Deflated Incurred Methods at Various Inflation Levels

Work Comp: Relativity of Unpaid Loss Indication to Regular Incurred Method Indication

Inflation	Deflated Inc (Full Val Case)	% Chg	Deflated Inc (PV Case)	% Chg	Deflated Paid	% Chg
3%	0.99		1.00		0.99	
4%	1.04	5.0%	1.05	4.7%	1.05	5.4%
5%	1.10	5.1%	1.10	4.8%	1.11	5.5%
6%	1.15	5.2%	1.15	4.8%	1.17	5.6%
7%	1.21	5.2%	1.21	4.9%	1.23	5.7%
8%	1.28	5.3%	1.27	5.0%	1.31	5.8%

Auto Liability: Relativity of Unpaid Loss Indication to Regular Incurred Method Indication

Inflation	Deflated Inc (Full Val Case)	% Chg	Deflated Inc (PV Case)	% Chg	Deflated Paid	% Chg
3%	1.00		1.00		1.01	
4%	1.02	2.3%	1.02	2.3%	1.03	2.2%
5%	1.05	2.3%	1.05	2.3%	1.05	2.2%
6%	1.07	2.3%	1.07	2.3%	1.08	2.2%
7%	1.09	2.3%	1.10	2.3%	1.10	2.2%
8%	1.12	2.3%	1.12	2.3%	1.12	2.2%

The first observation is that the choice of the adjuster to set case reserves at full or present value appears to be irrelevant—that is, we can move forward with either assumption regardless of what practice exists in reality and get a similar indication. The reason is that the increase in case reserve to account for inflation is a function of two variables: expected inflation and payment patterns; in an environment of relatively stable historical inflation (as we have had in the CPI the last 10 years) and stable loss payment patterns the variables are constant and produce a fixed factor. Thus, the adjuster's choice to incorporate expected inflation is just a decision of whether or not to increase every case reserve by a constant factor. Since the factor is stable we can deal with it two ways: (1) back out the factor directly, then determine development factors, or (2) make no adjustments, and have the factor unwind implicitly in the unadjusted development factors. Given reasonable LDF selections in both cases, it should not matter which approach we choose.

An issue arises when inflation, reserving or payment patterns are not stable throughout the historical data. If inflation spikes are present in the history then deflated incurred loss triangles that have not been adjusted for the assumed inflation built into case reserves will produce unreliable LDFs—in this case, historical LDFs would not all be inflated by a single stable factor (the factor

varies with adjusters' changing perception of inflation over time). In such a case it would be necessary for case reserves to be stated on a present value basis in the triangles. For this, clear communication is required between the reserving actuary and the claims department to determine if there have been changes in assumed inflation, or in other payment or reserving practices over time. It may be necessary to use different case reserve discount factors for different evaluation periods in the incurred loss triangles.

The second observation, that both deflated incurred methods and the deflated paid methods have similar sensitivity to inflation, should not be surprising. Regardless of what method is used, a matrix of incremental prospective loss payments is easy to derive based on the selected LDFs and assumed payment patterns or paid-to-incurred loss ratios. If all methods are using similar reasonable assumptions and have appropriate judgment applied in selecting the LDF factors, then the prospective paid loss matrices should be similar. It is this paid loss matrix that is sensitive to the assumed prospective inflation rate and so we should expect similar sensitivities in the methods.

For Workers Compensation, the Deflated Paid method was slightly more sensitive to changes in inflation (5% versus 4% per point increase in inflation). This is because the LDFs selected in the deflated paid method resulted in a greater proportion of losses projected to be paid in the tail compared to the deflated incurred method. That is, the difference in inflation sensitivity is due to a judgmental factor selection rather than an inherent difference in the two methods.

7. RESULTS AND CONCLUSIONS

At the most extreme levels of prospective inflation tested there would be significant reserve deficiencies among all lines of business. Even more modest inflation levels of 4% still show slight deficiencies among short-tail lines, and deficiencies as high as 10% for Workers Compensation (based on CPI Total Medical Services deflation). The results make intuitive sense since the economy has benefitted from low inflationary effects over the last couple of decades. While one would expect more of an effect of increased inflation for Auto Liability, most of the exposure is from Private Passenger Auto with limited development beyond 24 months.

The apparently odd results from the stock indices are likely due to the impact of real returns dwarfing the impact of the inflation component. The base level year is 1999 in these calculations, which is just before a crash in stock value. Thus, the "implied inflation" in the stock indices is negative over the observed period. Prospective inflation levels that are even slightly positive could be interpreted as "well above historical levels" given this perspective, so the deficiencies look severe. In a less volatile time period, or using a different base year the results may be less dramatic. We also

tested the loss severity fit against the S&P 500 Operating Results PE, with similar results to that observed for the S&P index.

For a given level of prospective inflation, the relative deficiency varies slightly depending on which index was used to deflate the loss triangles. As stated previously, removing the effect of real inflation is not likely to eliminate all trend observed in the data and each index provides insight into what that real historical inflation might have been. To the extent a given index over- or understates the true historical inflation, the resulting projected deficiency or redundancy can vary.

The final conclusion from this endeavor is that by applying Richards' methodology for a variety of indices and comparing the resulting range of estimates, one can glean valuable insight into understanding the potential impact on needed reserves when inflation changes.

Appendix 1: Coefficient of Determination (Ordinary Linear Least Squares/Linear Regression with AutoRegressive Errors)

Closed Claims by Closed Year

If two values are shown for a given cell, statistically significant autocorrelation was present in the error term.

Severity

Segment	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index
Commercial Liability	98	98	85	96	98	96	98	98	91	94
Commercial Property	93	93	77	89	92	89	92	93	90	93
Fire Lines Liability	95	96	79	93	96	94	96	96	94	96
Fire Lines Property	98	98	79	95	97	97	97	98	95	97
Health	92	91	81	89	91	88	91	92	89	92
Auto Liability	70/82	72/83	43/76	70/83	69/82	77	68/81	70/82	62	63
Other Liability	87	87	78	85	87	85	87	87	83	87
Auto Physical Damage	92	93	64	89	91	94	89	93	90	92
Special Property	90	91	78	93	93	93	92	90	80	82
Workers Compensation	96	95	91	97	97	93	97	96	83	87
All Lines	98	98	81	95	97	96	96	98	92	95

Segment	Dow Jones Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage
Commercial Liability	32/80	70/91	86	18/84	11/86	98	97	97	93
Commercial Property	35/75	64	90	21/78	14/80	93	94	94	87
Fire Lines Liability	34/84	64/88	83	19/87	11/88	96	96	96	91
Fire Lines Property	42/82	63/90	83	26/85	17/87	97	99	99	94
Health	27/74	69/85	89	14/77	7/79	92	91	91	85
Auto Liability	47	23/72	40/67	27/66	23/67	65/81	72	71	81
Other Liability	25	65	82	14/59	8/61	88	86	86	82
Auto Physical Damage	49	44/82	70	30/77	22/79	89	95	94	95
Special Property	39/76	63/80	64	22/75	14/74	90	88	89	89
Workers Compensation	36/79	78/89	80	22/81	14/82	98	93	95	90
All Lines	40/77	64/88	84	23/81	16/84	97	98	98	95

Loss Cost

Segment	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index
Commercial Liability	64	63	67	62	65	58	66	64	64	66
Commercial Property	71	70	70	68	67	63	68	71	57	64
Fire Lines Liability	33	32	47	32	33	25	35	33	30	33
Fire Lines Property	56	56	49	53	52	51	52	57	46	52
Health	87	88	56/83	82	86	90	84	88	93	93
Auto Liability	74	74	63	70	75	71	75	74	82	81
Other Liability	45	44	52/85	46	44	41	45	45/73	35	40
Auto Physical Damage	6	6	0	4	4	7	3	6	3	4
Special Property	42	42	31	42	40	45	39	42	34	37
Workers Compensation	82/90	82/91	84	82/91	84/92	77/91	85/92	82/90	81/91	84
All Lines	66	66	52	61	61	62	61	67	58	63

Segment	Dow Jones Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage
Commercial Liability	5/60	65	77	1/62	0/63	67	61	62	54
Commercial Property	21	63	79	11	7	71	69	69	65
Fire Lines Liability	0	52	53	1	3	37	30	31	23
Fire Lines Property	26	39	55	17	13	55	56	56	55
Health	46	37	70/89	27/77	19/80	83	91	90	55
Auto Liability	16/73	54	77	7/75	2/76	75	74	74	89
Other Liability	7	48/70	46/77	3	1	46	41	42	66/80
Auto Physical Damage	14	1	1	9	11	3	6	6	41/62
Special Property	32	20	24	20	17	39	41	41	11
Workers Compensation	26/84	79	82	17/86	10/86	87/93	81/91	82/91	47
All Lines	30	39	63	18	14	64	67	66	70/87

Appendix 2: Correlations Between Annual Changes in Severity by Line and Annual Changes in Various Indices

Correlations: Change in Index vs Change in Severity (1995-2009)

Segment	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index
Commercial Liability	17%	22%	-13%	5%	55%	17%	55%	19%	37%	33%
Commercial Property	40%	19%	34%	44%	17%	27%	13%	-52%	24%	23%
Fire Liability	20%	34%	-13%	-9%	82%	30%	78%	29%	41%	40%
Fire Property	-2%	-1%	-17%	-8%	-10%	-14%	-3%	-3%	40%	24%
Health	30%	33%	33%	41%	6%	15%	8%	9%	26%	12%
Auto Liability	-8%	-13%	-26%	0%	-13%	0%	-18%	-37%	-20%	-18%
Other Liability	22%	8%	5%	3%	-1%	26%	-6%	-27%	18%	27%
Auto Physical Damage	35%	52%	-23%	-2%	39%	-7%	38%	17%	30%	38%
Special Property	-55%	-42%	-40%	-51%	-1%	-8%	1%	28%	-7%	-21%
Workers Compensation	-13%	16%	-34%	-41%	-13%	-19%	-14%	44%	8%	10%

Segment	Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage
Commercial Liability	-18%	-18%	4%	-22%	-20%	11%	25%	24%	-10%
Commercial Property	-35%	10%	23%	-31%	-30%	16%	23%	21%	46%
Fire Liability	2%	-15%	5%	-3%	-4%	22%	23%	24%	7%
Fire Property	4%	24%	38%	3%	0%	-7%	19%	18%	-10%
Health	-38%	37%	50%	-44%	-45%	27%	24%	21%	8%
Auto Liability	15%	-36%	-36%	14%	16%	-34%	-4%	-5%	41%
Other Liability	4%	-19%	5%	4%	3%	16%	9%	5%	41%
Auto Physical Damage	18%	-31%	12%	12%	13%	9%	40%	41%	29%
Special Property	38%	12%	-12%	34%	31%	-36%	-25%	-21%	-35%
Workers Compensation	44%	-24%	-13%	52%	51%	6%	12%	16%	-32%

Correlations: 3-Year Rolling Change in Index vs Change in Severity (1995-2009)

Segment	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index
Commercial Liability	-22%	3%	-44%	-48%	52%	21%	44%	24%	61%	53%
Commercial Property	22%	53%	27%	21%	71%	25%	68%	16%	69%	69%
Fire Liability	-2%	37%	-10%	-12%	85%	28%	78%	22%	71%	66%
Fire Property	-26%	19%	-12%	-22%	61%	29%	56%	10%	76%	67%
Health	34%	57%	61%	58%	68%	15%	70%	26%	40%	41%
Auto Liability	-50%	-53%	-74%	-50%	-60%	31%	-72%	-58%	-42%	-49%
Other Liability	18%	40%	-22%	-8%	39%	53%	26%	6%	45%	42%
Auto Physical Damage	-28%	-12%	-76%	-62%	-3%	32%	-17%	-14%	15%	9%
Special Property	-65%	-34%	-21%	-17%	27%	33%	20%	-36%	9%	-4%
Workers Compensation	8%	-10%	-32%	-47%	-54%	-47%	-47%	22%	2%	6%

Segment	Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage
Commercial Liability	7%	-23%	-12%	5%	3%	-13%	18%	18%	-10%
Commercial Property	-55%	34%	63%	-46%	-49%	39%	12%	5%	-24%
Fire Liability	-39%	6%	28%	-38%	-41%	11%	2%	-2%	-10%
Fire Property	-32%	9%	39%	-25%	-30%	5%	5%	2%	-21%
Health	-81%	60%	87%	-75%	-78%	54%	-12%	-20%	-28%
Auto Liability	59%	-83%	-71%	47%	52%	-87%	3%	15%	77%
Other Liability	-15%	-27%	40%	-22%	-21%	-15%	34%	35%	38%
Auto Physical Damage	46%	-72%	-44%	36%	38%	-61%	24%	32%	53%
Special Property	-31%	-10%	0%	-35%	-36%	-37%	-48%	-44%	21%
Workers Compensation	78%	-20%	-40%	84%	82%	0%	49%	50%	-27%

Appendix 3: Correlations Between Annual Changes in Loss Cost by Line and Annual Changes in Various Indices

Correlations: Change in Index vs Change in Total Loss Cost (1995-2009)

Segment	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index
Commercial Liability	32%	27%	22%	17%	60%	1%	65%	14%	19%	26%
Commercial Property	55%	29%	46%	46%	24%	40%	19%	-28%	10%	18%
Fire Liability	34%	37%	18%	9%	66%	19%	64%	32%	12%	20%
Fire Property	45%	39%	17%	18%	29%	20%	28%	32%	3%	8%
Health	52%	65%	9%	39%	10%	28%	6%	4%	47%	40%
Auto Liability	43%	34%	8%	12%	55%	-4%	59%	9%	31%	35%
Other Liability	15%	-5%	-1%	-5%	-15%	7%	-17%	-31%	6%	15%
Auto Physical Damage	48%	39%	-9%	15%	23%	10%	21%	14%	-3%	2%
Special Property	11%	4%	23%	20%	-39%	-16%	-37%	-22%	-5%	4%
Workers Compensation	1%	30%	10%	-21%	22%	-21%	29%	44%	43%	44%

Segment	Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage
Commercial Liability	-24%	12%	13%	-29%	-29%	37%	10%	8%	-1%
Commercial Property	-30%	4%	16%	-35%	-34%	42%	19%	16%	58%
Fire Liability	-11%	-8%	5%	-14%	-14%	42%	13%	13%	3%
Fire Property	-2%	-8%	17%	-14%	-13%	42%	28%	26%	26%
Health	-28%	-10%	62%	-32%	-32%	13%	55%	54%	36%
Auto Liability	-7%	3%	23%	-13%	-13%	35%	22%	19%	12%
Other Liability	17%	-17%	-1%	17%	16%	9%	4%	0%	37%
Auto Physical Damage	13%	-31%	20%	-4%	-3%	6%	23%	23%	53%
Special Property	12%	32%	-5%	6%	7%	10%	-1%	0%	22%
Workers Compensation	3%	30%	14%	17%	13%	54%	17%	15%	-53%

Correlations: 3-Year Rolling Change in Index vs Change in Loss Cost (1995-2009)

Segment	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index
Commercial Liability	31%	32%	33%	20%	76%	-24%	82%	38%	43%	45%
Commercial Property	68%	54%	68%	71%	46%	1%	50%	20%	4%	14%
Fire Liability	62%	46%	49%	38%	54%	-41%	64%	50%	21%	28%
Fire Property	50%	10%	27%	37%	-23%	-20%	-19%	15%	-50%	-41%
Health	-18%	35%	-45%	-28%	33%	86%	12%	1%	50%	44%
Auto Liability	18%	17%	-5%	-17%	55%	-24%	58%	30%	51%	48%
Other Liability	14%	-6%	-39%	-28%	-30%	4%	-34%	-10%	-3%	-4%
Auto Physical Damage	-23%	-35%	-64%	-42%	-36%	24%	-47%	-32%	-33%	-38%
Special Property	31%	-9%	33%	34%	-55%	-29%	-47%	-20%	-64%	-52%
Workers Compensation	50%	56%	60%	32%	55%	-49%	70%	58%	56%	62%

Segment	Dow Jones Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage
Commercial Liability	-45%	50%	28%	-42%	-45%	53%	-16%	-24%	-46%
Commercial Property	-61%	54%	57%	-61%	-61%	58%	-8%	-15%	-9%
Fire Liability	-34%	55%	27%	-30%	-32%	67%	-2%	-11%	-48%
Fire Property	8%	8%	-9%	0%	3%	17%	2%	2%	14%
Health	-7%	-53%	31%	-12%	-12%	-43%	39%	43%	51%
Auto Liability	-7%	18%	3%	-6%	-9%	28%	5%	0%	-33%
Other Liability	42%	-42%	-14%	34%	36%	-29%	36%	39%	38%
Auto Physical Damage	53%	-71%	-65%	38%	42%	-66%	6%	16%	69%
Special Property	14%	15%	-10%	11%	13%	11%	-14%	-13%	19%
Workers Compensation	-42%	78%	65%	-27%	-32%	86%	11%	-2%	-85%

Appendix 4: Indicated Ratio of Needed to Carried Reserves at Varying Inflation Assumptions

Based on methodology derived by Mr. William Richards, 1981

Inflation amount	CPI	CPI Housing	CPI Motor Vehicle Parts	CPI Motor Vehicle Maintenance	CPI Total Medical Care	CPI Medical Care Commodities	CPI Medical Services	CPI All Items Less Food	Houses Sold Pricing Index	Fisher Index	Dow Jones Industrial Average	Gold	Oil	Russell 3000	S&P 500	GDP Deflator	GDP Per Capita	Relative Share of GDP	Unskilled Wage	Max	Min
Commercial Liability																					
2%	99%	99%	97%	97%	96%	100%	95%	100%	100%	99%	114%	79%	69%	122%	122%	99%	96%	95%	100%	122%	69%
4%	106%	106%	104%	105%	104%	108%	103%	108%	108%	106%	124%	85%	74%	132%	133%	107%	104%	102%	107%	133%	74%
6%	115%	115%	113%	113%	112%	116%	111%	116%	117%	115%	134%	91%	80%	143%	144%	116%	112%	110%	116%	144%	80%
8%	124%	124%	122%	122%	121%	126%	120%	126%	126%	124%	145%	98%	86%	155%	156%	125%	121%	119%	125%	156%	86%
10%	134%	134%	132%	132%	131%	136%	130%	136%	137%	134%	157%	105%	93%	168%	169%	135%	131%	128%	136%	169%	93%
Commercial Property																					
2%	101%	101%	100%	100%	100%	102%	99%	102%	104%	103%	115%	86%	102%	120%	120%	101%	100%	99%	101%	120%	86%
4%	103%	104%	103%	102%	102%	104%	102%	104%	107%	106%	118%	88%	105%	123%	123%	104%	103%	102%	103%	123%	88%
6%	106%	106%	105%	105%	105%	107%	105%	107%	110%	109%	121%	90%	107%	126%	126%	107%	106%	105%	106%	126%	90%
8%	109%	109%	108%	108%	108%	110%	107%	110%	113%	111%	124%	92%	110%	129%	129%	109%	108%	107%	109%	129%	92%
10%	112%	112%	111%	110%	111%	113%	110%	113%	115%	114%	127%	95%	112%	132%	132%	112%	111%	110%	112%	132%	95%
Fire Liability																					
2%	96%	97%	95%	95%	94%	98%	93%	98%	100%	98%	115%	71%	76%	123%	123%	97%	95%	93%	97%	123%	71%
4%	101%	101%	99%	99%	99%	102%	98%	102%	104%	103%	120%	74%	79%	128%	129%	102%	99%	97%	101%	129%	74%
6%	106%	106%	104%	104%	103%	107%	102%	107%	109%	108%	126%	77%	82%	135%	135%	106%	104%	102%	106%	135%	77%
8%	111%	111%	109%	109%	108%	112%	107%	112%	115%	113%	132%	80%	86%	141%	142%	111%	109%	107%	111%	142%	80%
10%	116%	116%	114%	114%	113%	118%	112%	118%	120%	118%	139%	84%	90%	148%	149%	117%	114%	112%	117%	149%	84%
Fire property																					
2%	99%	99%	99%	98%	98%	100%	98%	100%	103%	102%	116%	85%	100%	121%	121%	100%	99%	98%	99%	121%	85%
4%	102%	102%	101%	100%	101%	102%	100%	103%	105%	104%	119%	87%	102%	124%	124%	102%	101%	100%	101%	124%	87%
6%	104%	104%	103%	103%	103%	105%	103%	105%	108%	107%	122%	89%	105%	127%	127%	105%	104%	103%	104%	127%	89%
8%	106%	107%	106%	105%	106%	107%	105%	108%	110%	109%	125%	91%	107%	130%	130%	107%	106%	105%	106%	130%	91%
10%	109%	109%	108%	108%	108%	110%	107%	110%	113%	112%	128%	93%	109%	133%	133%	110%	109%	108%	109%	133%	93%
Health																					
2%	90%	90%	89%	90%	91%	90%	91%	90%	91%	91%	94%	108%	97%	96%	96%	90%	91%	91%	90%	108%	89%
4%	95%	95%	94%	96%	96%	95%	96%	95%	96%	96%	99%	115%	102%	101%	101%	95%	96%	97%	95%	115%	94%
6%	101%	101%	100%	101%	101%	101%	102%	100%	102%	102%	104%	123%	108%	107%	106%	101%	102%	102%	101%	123%	100%
8%	107%	107%	106%	108%	108%	107%	108%	107%	108%	108%	110%	131%	114%	113%	112%	107%	108%	109%	107%	131%	106%
10%	114%	114%	113%	115%	115%	114%	115%	113%	115%	115%	117%	140%	120%	120%	119%	114%	115%	116%	114%	140%	113%
Auto Liability																					
2%	93%	93%	93%	92%	91%	93%	90%	93%	90%	89%	99%	77%	64%	102%	103%	94%	91%	89%	94%	103%	64%
4%	98%	97%	97%	96%	95%	98%	94%	98%	93%	93%	103%	80%	66%	106%	108%	98%	94%	93%	98%	108%	66%
6%	102%	101%	101%	101%	99%	102%	98%	102%	98%	97%	108%	84%	69%	111%	113%	102%	99%	97%	103%	113%	69%
8%	106%	106%	106%	105%	103%	107%	102%	107%	102%	102%	113%	87%	72%	116%	118%	107%	103%	101%	107%	118%	72%
10%	111%	111%	111%	110%	108%	111%	107%	111%	106%	106%	118%	91%	75%	122%	123%	111%	108%	105%	112%	123%	75%
Other Liability																					
2%	87%	88%	86%	86%	86%	89%	85%	89%	91%	90%	110%	66%	68%	118%	119%	88%	86%	84%	88%	119%	66%
4%	93%	94%	92%	92%	92%	95%	91%	95%	97%	96%	118%	70%	72%	127%	127%	94%	92%	90%	94%	127%	70%
6%	100%	100%	98%	98%	98%	102%	97%	102%	104%	103%	126%	75%	77%	136%	137%	101%	98%	96%	100%	137%	75%
8%	107%	108%	105%	105%	105%	109%	104%	109%	112%	110%	136%	80%	82%	146%	147%	108%	105%	103%	108%	147%	80%
10%	115%	116%	113%	113%	113%	117%	111%	118%	120%	118%	146%	85%	87%	157%	158%	116%	113%	111%	116%	158%	85%
Auto Physical Damage																					
2%	98%	97%	99%	97%	98%	96%	98%	97%	97%	98%	98%	105%	122%	97%	97%	97%	98%	99%	96%	122%	96%
4%	98%	97%	99%	97%	97%	96%	98%	97%	97%	97%	97%	106%	123%	96%	96%	97%	98%	98%	95%	123%	95%
6%	97%	96%	98%	96%	97%	95%	97%	96%	96%	97%	96%	107%	124%	94%	95%	96%	97%	98%	94%	124%	94%
8%	96%	95%	97%	95%	96%	94%	96%	95%	95%	96%	95%	107%	125%	93%	93%	95%	96%	97%	93%	125%	93%
10%	95%	93%	96%	94%	95%	93%	95%	94%	94%	95%	93%	107%	126%	91%	91%	93%	95%	96%	92%	126%	91%
Special Property																					
2%	100%	100%	100%	99%	99%	100%	99%	101%	103%	102%	114%	91%	109%	118%	118%	100%	100%	99%	99%	118%	91%
4%	102%	103%	102%	101%	102%	103%	101%	103%	106%	105%	116%	93%	112%	120%	120%	103%	102%	102%	102%	120%	93%
6%	105%	105%	105%	104%	104%	105%	104%	106%	108%	107%	119%	95%	114%	123%	123%	105%	105%	104%	104%	123%	95%
8%	107%	108%	107%	106%	107%	108%	106%	108%	111%	110%	122%	98%	117%	126%	126%	108%	107%	107%	107%	126%	98%
10%	110%	110%	110%	109%	109%	111%	109%	111%	113%	113%	125%	100%	119%	129%	129%	110%	110%	109%	109%	129%	100%
Workers Compensation																					
2%	104%	103%	103%	103%	102%	103%	102%	103%	100%	100%	105%	109%	81%	108%	108%	103%	102%	101%	104%	109%	81%
4%	112%	112%	111%	112%	110%	112%	110%	112%	108%	109%	114%	118%	87%	117%	118%	112%	110%	109%	113%	118%	87%
6%	122%	121%	121%	121%	120%	121%	119%	121%	118%	118%	124%	128%	94%	128%	128%	122%	120%	119%	123%	128%	94%
8%	132%	132%	131%	132%	130%	132%	130%	132%	128%	128%	135%	138%	102%	139%	140%	132%	130%	129%	133%	140%	102%
10%	144%	143%	143%	144%	142%	144%	141%	143%	139%	139%	147%	150%	111%	151%	152%	144%	141%	140%	145%	152%	111%

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An Analysis of the Limitations of Utilizing the Development Method for Projecting Mortgage Credit Losses and Recommended Enhancements

Michael Schmitz, FCAS, and Kyle Mrotek, FCAS

Abstract: The rise and fall of subprime mortgage securitizations contributed in part to the ensuing credit crisis and financial crisis of 2008. Some participants in the subprime-mortgage-backed securities market relied at least in part on analyses grounded in the loss development factor (LDF) method, and many did not conduct their own credit analyses, relying instead on the work of others such as securities brokers and rating agencies. In some cases, the parties providing these analyses may have lacked the independence, or at least the appearance of it, that would have likely better served the market.

A new appreciation for the value of independent analysis is clearly a silver lining and an important lesson to be taken from the crisis. Actuaries are well positioned to lend assistance to the endeavor.

Mortgages are long-duration assets and, similarly, mortgage credit losses are relatively long-tailed. As casualty actuaries are aware, the LDF method has inherent limitations associated with immature development. The authors in this paper will cite examples of parties relying on the LDF or similar methods for projecting subprime mortgage credit losses, highlight the limitations of relying exclusively on such methods for projecting subprime mortgage credit performance, and conclude by offering general enhancements for an improved approach that considers the underwriting characteristics of the underlying loans as well as economic factors.

Keywords. Mortgage, credit risk, cash flow modeling, credit crisis, cash flow modeling, independence

1. INTRODUCTION

The rise and fall of subprime mortgage securitizations contributed in part to the ensuing credit crisis and financial crisis of 2008. Some participants in the subprime-mortgage-backed securities market did not conduct their own credit analyses, relying instead on the work of others such as securities brokers and rating agencies. In some cases, the parties providing these analyses may have lacked the independence, at least in appearance, which would have likely served the market better.

A new appreciation for the value of independent analysis is clearly a silver lining and an important lesson to be taken from the crisis. Actuaries are well positioned to lend assistance to the endeavor. In fact, actuaries might be interested to learn that several market participants have relied at least in part on analyses grounded in the loss development factor (LDF) method.

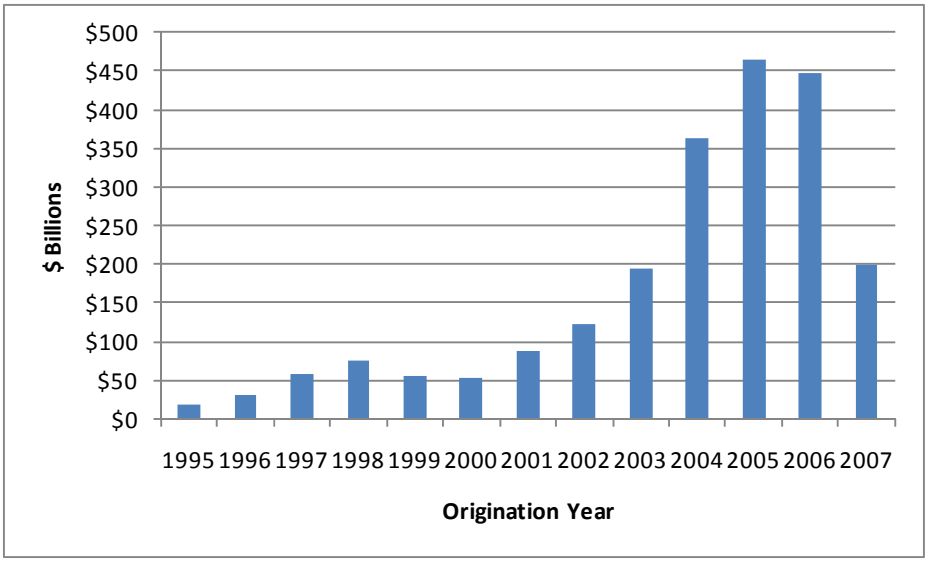
Mortgages are long-duration assets and, similarly, mortgage credit losses are relatively long-tailed. As casualty actuaries are aware, the LDF method has inherent limitations associated with immature development. The authors in this paper will cite examples of parties relying at least in part on the LDF or similar methods for projecting subprime mortgage credit losses, highlight the limitations of

relying exclusively on such methods for projecting subprime mortgage credit performance, and conclude by offering general enhancements for an improved approach that considers the underwriting characteristics of the underlying loans, as well as economic factors.

2. Mortgage-Backed Securities: Whose Analysis and for What Purpose?

Despite the tremendous growth of funds flowing into mortgage-backed securities (MBS) during the period 2004-2006, it's arguable that there was altogether too little independent analysis conducted in critical parts of this market space. Figure 1 illustrates the growth in subprime MBS gross issuance by origination year.

Figure 1: Subprime MBS Gross Issuance by Origination Year



Source: Subprime Mortgage Credit Derivatives, Goodman, et al., (Frank J. Fabozzi series).

Many investors searching for extra yield in the low-interest-rate environment of the time viewed MBS as a safe way to add alpha, or extra return to their portfolios. After all, the securities were rated AAA and backed by collateral that seemed solidly dependable: ever-rising home values and the ability of borrowers to pay their mortgages or refinance into subprime mortgages via cashing out on the additional equity that rising prices offered.

Subprime MBS market participants often relied on the security ratings provided by credit rating agencies, even though credit rating agencies do not necessarily intend their ratings to be used for

buy/hold/sell decisions. Instead, they provide opinions on "the risk to the debtholder of not receiving timely payment of principal and interest on this specific debt security."[1]

Despite this description of the intent of the rating, investors have tended to rely on them, perhaps to no fault of the credit rating agencies. For example, the ratings of MBS tend to affect insurance company investment decisions just as it did for many investors. "Credit opinions have long served as a fundamental barometer for NAIC policy formulations tied to invested assets," notes a National Association of Insurance Commissioners (NAIC) staff report.[2]

> The NAIC first accepted credit ratings as evidence that a security was "amply secured," which permitted the insurer to use amortized accounting. Credit opinions were then used to drive decisions about the value of securities. With the adoption of the Mandatory Securities Valuation Reserve (the precursor to the current Asset Valuation and Interest Maintenance Reserves), credit opinions were used to set reserving levels. Today, credit opinions serve as switches in a number of regulatory activities… Insurers need not file any NRSRO-rated securities with the SVO and instead self assign an NAIC designation to the security in accordance with a prescribed equivalency formula.

The MBS holdings of NAIC insurance companies are not trivial. According to the American Council of Life Insurers (ACLI), life and health insurers held $145 billion of non-agency MBS at year-end 2008,[3] plus $384 billion of agency MBS, for a total of $529 billion. As a note, non-agency mortgage-related securities outstanding at year-end 2009, not just for the life/health insurance industry, but in total, amounted to $2.4 trillion according to the Securities Industry and Financial Markets Association (SIFMA).

Another issue investors should consider is that some third parties providing analysis of MBS may lack the independence that might better serve the role (or at least the appearance of a potential lack of independence). For example, the potential for conflicts of interest can exist when relying on broker-dealer quotes for valuation estimates. First, the investor is asking the broker-dealer to analyze or value an asset that the broker-dealer is in the business of transacting with investors. Furthermore, the quotes provided by broker-dealers are not necessarily consistent with intrinsic values, but rather, might represent the quotes at which the broker-dealer is willing to buy or sell. This input results in a valuation akin to a market valuation (never mind that the market for price discovery is not always deep or transparent). There is considerable benefit to be gained from an intrinsic valuation of the MBS securities (along with a risk assessment of the securities). Furthermore, an intrinsic valuation can have accounting implications as discussed below.

For financial reporting purposes, an intrinsic valuation may be useful in order to separate impairment items that are fundamental, such as credit from items that are temporary but impacting market prices such as liquidity. FASB Staff Position (FSP) 115-2 "requires the recognition of an OTTI [other than temporary impairment] charge if the present value of cash flows of a debt security expected to be collected is less than the amortized cost basis of the debt security. The intent is to help companies avoid taking unnecessary write-downs to securities unless there is a true credit loss. The FSP also requires the OTTI to be split into credit and non-credit portions, where the credit portion is reflected on the income statement. As the market values of many securities are well below their present value of estimated cash flows even after consideration of projected defaults, the non-credit portion of the loss can be reflected as Other Comprehensive Impairment (OCI) in the shareholder equity section of the balance sheet and not on the income statement."[4] Pure market valuations alone do not provide this decomposition.

As reported by the *Wall Street Journal*, even third parties not participating in trade at the surface may have institutional relationships with traders.[5] The ACLI requested that the NAIC consider modifying its approach to developing NAIC ratings for residential mortgage-backed securities (RMBS).[6] In October 2009, the NAIC issued a request for proposal to generate responses from interested and qualified parties to work with the NAIC to help establish ratings for 18,000 RMBSs estimated to be owned by U.S. insurers at year-end 2009. The results of the analysis were to be used for statutory financial reporting at year-end and to determine RBC requirements.[7] One of the qualifications necessary for a firm to be considered for the engagement was that it have "safeguards in place to avoid conflict of interest, both in fact and appearance."

The NAIC ultimately selected PIMCO Advisory, a unit of PIMCO, "a leading global investment management firm ... manag[ing] investments for an array of clients, including retirement and other assets that reach more than 8 million people in the U.S. and millions more around the world," including bond fund PIMCO Mortgage-Backed Securities Fund (PTRIX), and also a unit of Allianz, with more than €8 billion of corporate (i.e., non-agency) residential or corporate MBS (R/CMBS) as of year-end 2009,[8] not to mention life, health, and property/casualty insurance companies with premiums for year 2009 of €10 billion in the United States alone,[9] much of which is under the domain of the NAIC.

2.1 Type of Analysis

The increased importance of independent risk analysis and intrinsic values of MBS holdings highlights the importance of sound credit risk analysis. The critical factors to driving credit losses are the underwriting characteristics of the underlying mortgage loans and the economic conditions to which those loans are exposed. The mortgage credit loss estimation process generally involves the following three main components:

- Loss frequency or default rate
- Loss severity (the magnitude of credit losses on defaulting loans)
- Loss emergence pattern (the timing of loss incidence for a block of loans underwritten in a particular vintage)

Note that the last factor suggests the deployment of development types of projections may be useful. However, practitioners must consider the limitations of such methods and also the impact of the underwriting quality and economic factors referenced above.

The estimation of each of the three components above is interrelated and some applied methods are briefly described. Frequencies, or default rates, are sometimes measured separately from severities, and sometimes the two are combined into loss rates (losses as a percentage of original loan balance in a given vintage). Most of the approaches referred to below for default rates can be utilized for loss rates as well.

Default frequencies can be measured as the percentage of loans originated in a cohort that ultimately gives rise to a mortgage credit loss. This can be expressed on a count basis or on a dollar-weighted average basis and the frequencies are generally referred to as default rates.

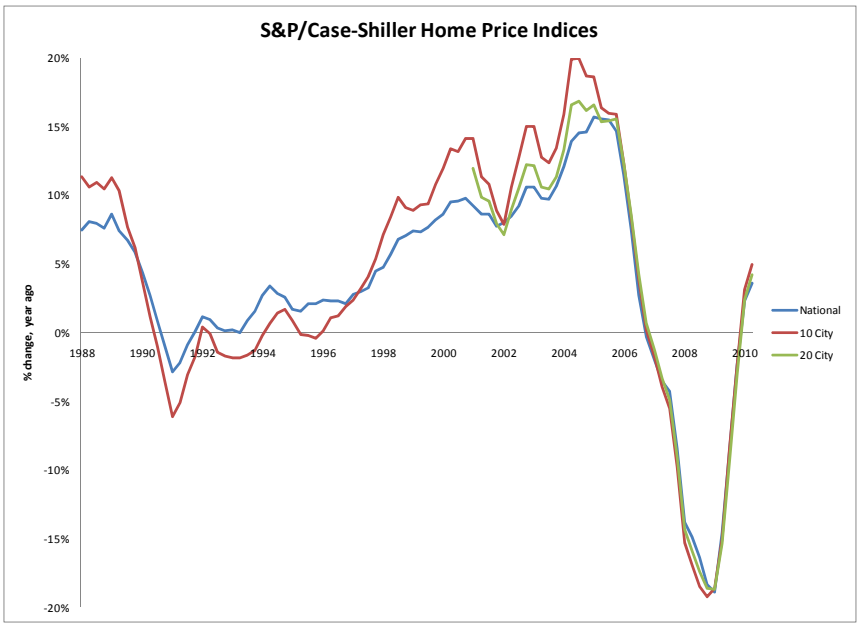
Practitioners take various approaches to this estimation process, but generally start with a review of historical data in order to project future losses after adjustments for development, trends in the book of business, changes in risk profile, etc. A particular practitioner's or company's data may be supplemented by relevant external data such as industry experience and other relevant sources.

Some practitioners have also developed proprietary underwriting models that estimate default rates and severities based on underwriting characteristics of loans. These models are in turn calibrated by analyzing historical data and can be factored into the loss estimation process. Econometric models have also been employed for analyzing historical default rates as a function of certain economic variables. Such an approach is particularly useful for reviewing past performance

because of the strong influence of economic factors on mortgage credit losses, and for sensitivity testing of forecasts to various scenarios of economic conditions.

Mortgage credit loss analysis should rely on reviewing the long-term historical experience, especially in determining tail risk, in order to capture the economically cyclical nature of mortgage performance stemming from the underlying correlation of individual mortgages as a result of economic impacts. This long-term perspective is a critical consideration for mortgage credit loss analysis and may have been overlooked by many participants that calibrated their models to the relatively benign experience during the late 1990s and early 2000s, which was characterized by steadily increasing home prices, as shown in Figure 2.

Figure 2: S&P/Case-Shiller Home Price Indices



The default loss estimation process can generally involve analyzing losses on an origination or loan underwriting vintage basis. This involves grouping all loans into the period in which the loan was originated or underwritten. Data is grouped to balance the homogeneity of risks with the credibility of their loss experience. New loan products and risk categories with limited histories are frequently analyzed based on the relative performance over their limited loss histories. Then, the more credible longer-term experience of risks with more exposure throughout robust loss cycles can be used to augment the risk evaluated.

It takes many years before the actual ultimate default frequencies for an origination cohort are known with relative confidence because of the long-term nature of mortgage credit risk (loans can remain outstanding for up to 30 years or more after a loan is underwritten). Peak default incidence tends to occur three to seven years after origination, and it is therefore necessary to project the ultimate default rates for more recent cohorts based on patterns of loss emergence exhibited by older and more mature loan vintages.

Loss development techniques can be employed for this purpose. As mentioned above, data is generally grouped into segments in an attempt to balance homogeneous risk characteristics and credibility (the predictive value of a segment of data). As a group of loans ages, their collective sum of default losses (either paid or "incurred," where "incurred" includes a provision for losses on loans that have become delinquent but have not been foreclosed upon or liquidated). Equivalently, their collective incurred or paid loss rates or claim rates similarly change. This change in value over time can be modeled as loss development.

Quite familiar to casualty actuaries, the loss development factor (LDF) method is a traditional actuarial approach that relies on the historical changes in losses from one evaluation point to another to project the current valuation of loss to an ultimate loss basis. Development patterns that have been exhibited by more mature (older) cohorts and historical industry experience are used to estimate the expected development of the less mature (more recent) cohorts. Thus, development methods can be useful methods, though practitioners should consider the underwriting characteristics and economic conditions mentioned above, as well as changes in persistency of loans when using development methods.

2.2 Limitations of Development Methods as They Relate to Mortgage Credit Losses

The chief limitation of development methods as they related to forecasting mortgage credit losses stems from the need to consider the impact of the underwriting quality of the loans and the economic conditions to which the loans are exposed, as discussed below.

RMBSs are certainly long-duration assets, with payments to an investor of an RMBS stretching over 30 years or even longer. While average durations of subprime MBS with high pre-payment rates tended to be quite a bit shorter before the crisis (e.g., durations of three to six years), pre-payment rates have dropped considerably since the crisis while falling home prices have eroded equity and

lenders have tightened credit. This has caused an exposure extension that also should be considered in the analysis as discussed below.

One mortgage product feature that gained in popularity is the 40-year term mortgage. The 40-year term mortgage was more or less rolled out in the 1980s when mortgage rates were double digits.[10] By extending the term of the mortgage, monthly payments are reduced, and therefore, borrowers can *afford* more house. Of course, this stretching out of the payback period results in the borrower having less equity in the property, as principal balance is paid down more slowly.

In May 2006, 40-year mortgages represented 5% of new mortgages in the United States and 25% of new mortgages in California, where house prices were even more out of reach for many borrowers. Just as house prices in the United States were reaching a peak in mid-2006, mortgages with 50-year terms were starting to gain traction.[11] Figure 2 illustrates that home prices were increasing, even if at a decreasing rate, through mid-2006.

Similarly, mortgage credit losses are also relatively long-tailed. Depending on the type of residential mortgages, the midpoint for mortgage credit losses in a pool can range from three to seven years, but the full development of credit losses can theoretically extend out almost as long as the mortgage term, up to 30 years (although losses that far out are generally negligible).

As casualty actuaries are aware, the LDF method has inherent limitations associated with immature development. The difficulty that development methods encountered with respect to forecasting mortgage collateral loss was its key assumption, which does not always hold in the case of mortgage collateral. "The distinguishing characteristic of the development method is that ultimate claims [collateral loss] for each accident year [vintage] are produced from recorded values assuming that future claims' development is similar to prior years' development," writes Friedland.[12]

Development methods can be unreliable when the loss experience is susceptible to calendar-year effects, which affect triangle diagonals. Friedland elaborates about when the development method works and when it does not:

> The development technique is based on the premise that we can predict future claims activity for an accident year (or policy year, report year, etc.) based on historical claims activity to date for that accident year. The primary assumption of this technique is that the reporting and payment of future claims will be similar to the patterns observed in the past. When used with reported claims, there is an implicit assumption that there have been no significant changes in the adequacy of case outstanding during the experience period; when used with paid claims, there is an implicit assumption that there have been no significant changes during the

> experience period in the speed of claims closure and payment. Thus, the development method is appropriate for insurers in a relatively stable environment. When there are no major organizational changes for the insurer, and when there are no major external environmental changes, the development technique is an appropriate method to use in combination with other techniques for estimating unpaid claims.
>
> However, if there are any changes to the insurer's operation (e.g., new claims processing systems; revisions to tabular formulae for case outstanding; or changes in claims management philosophy, policyholder deductibles, or the insurer's reinsurance limits), the assumption that the past will be predictive of the future may not hold true. Environmental changes can also invalidate the primary assumption of the development technique. For example, when a major tort reform occurs (such as a cap on claim settlements or a restriction in the statute of limitations), actuaries may no longer be able to assume that historical claim development experience will be predictive of future claims experience. In such situations, the actuary should consider alternative techniques for estimating unpaid claims, or at the very least, adjust the selected claim development factors.[13]

The inherent risk profile of loans changed markedly, leading up to the mortgage credit crisis stemming from the severe decline in the underwriting quality of the loans. Coupled with that, environmental changes occurred with respect to the performance of mortgages as home prices reached an unusually high peak in mid-2006 and then started a steep descent.

The underwriting quality of loans packaged into non-agency MBS declined as referenced above. The change occurred similarly across product types from prime to Alt-A to subprime. Figure 3 highlights the decay in underwriting for subprime adjustable-rate mortgages (ARMs) for select collateral characteristics by origination year (OY).

Figure 3: Select Collateral Characteristics for Subprime ARM

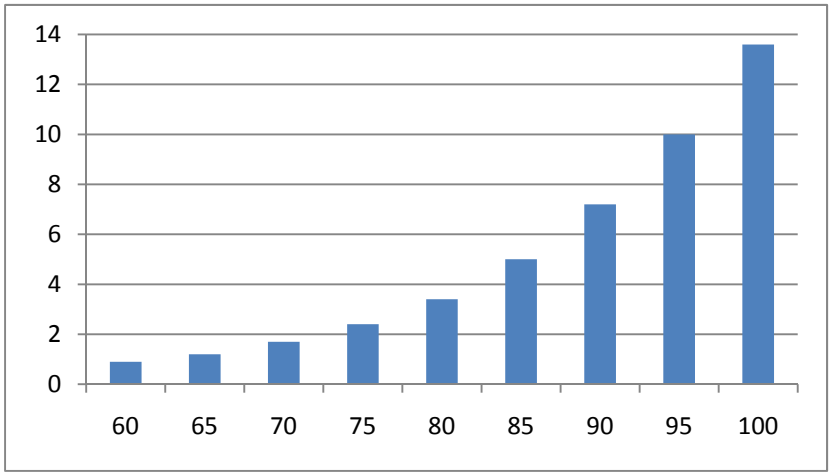
Collateral Characteristics Subprime ARMs							
OY	CLTV	% IO	% 40 Yr	% Piggyback	% CLTV > 80%	% CLTV > 90%	% Full Doc
2001	81	0	0	4	45	25	71
2002	81	1	0	4	47	27	66
2003	84	6	0	11	56	38	63
2004	85	21	0	20	61	45	59
2005	87	33	8	29	64	51	55
2006	88	20	31	34	69	56	53
2007	85	19	28	20	64	49	57

Source: Subprime Mortgage Credit Derivatives, Goodman, et al., (Frank J. Fabozzi series).

Interest-only (IO) loans began the 2000 decade with negligible representation and then exceeded 19% for four years from 2004 to 2007. Similarly, 40-year terms and loans with piggybacks also

experienced growth from virtually nothing to sizeable representation. Further, the proportion of loans with full documentation declined from more than two-thirds to about one-half. The increase in combined loan to value ratio (CLTV) from 81% to its peak at 88% can be exaggerated by speaking to its complement: borrower equity decreased from 19% to 12%. What's more, the increase in the proportion of loans with CLTV exceeding 80% went from about one-half to two-thirds, while the proportion of loans with CLTV exceeding 90% increased from one-quarter to one-half. This increase has a substantial impact on underwriting quality because frequency of default and CLTV are not linearly related—but rather, default frequency increases at a degree higher than one. Figure 4 illustrates the higher magnitude relationship between median foreclosure frequency and LTV for borrowers with a FICO credit score of 620 and otherwise generally vanilla underwriting characteristics.

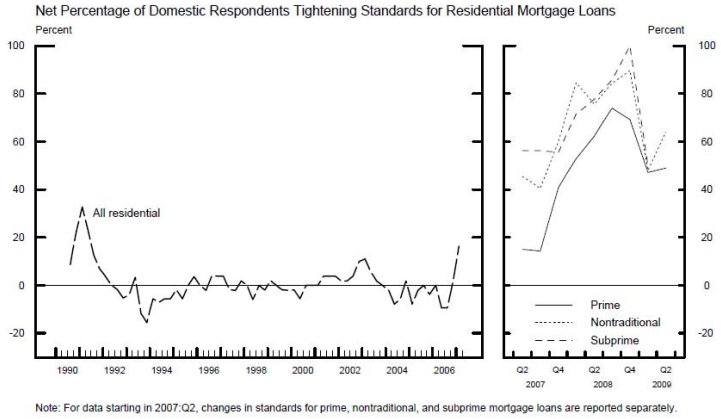
Figure 4: Relationship Between Foreclosure Frequency and LTV



Source: Fitch IBCA Residential Mortgage-Backed Securities Criteria

The rising tide of home price appreciation that obscured mortgage credit risk during the housing boom quickly reversed course into home price depreciation, which magnified credit risk markedly. And, while home prices experienced an unprecedented decline, the availability of credit to weak borrowers only diminished further, which reinforced the price declines in a credit-risk-amplifying feedback loop. Figure 5 illustrates the tightening of standards for residential mortgage loans based on the Federal Reserve's survey of bank lending practices.

Figure 5: Net Percentage of Domestic Respondents Tightening Standards for Residential Mortgage Loans



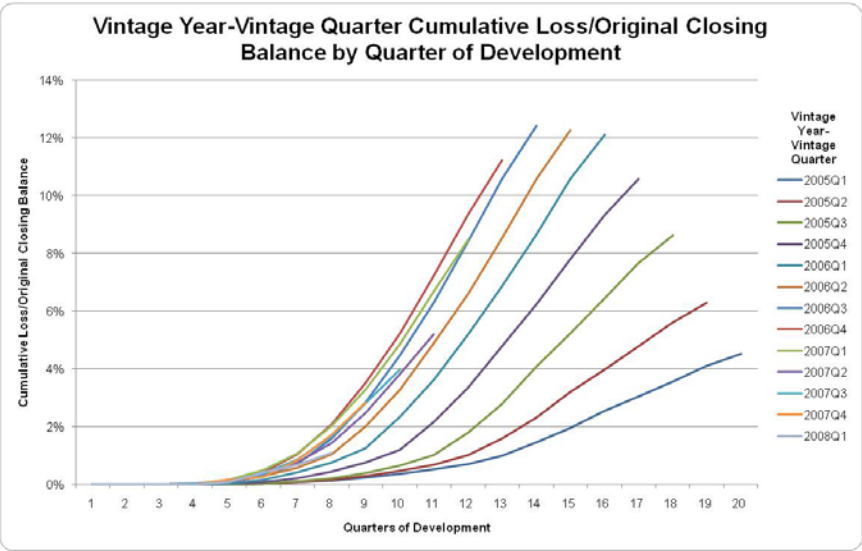
Source: Federal Reserve

We compiled vintage quarter cumulative loss rates using LoanPerformance's mortgage securities database to demonstrate the calendar-year effect. The database represents a significant portion of mortgage collateral underlying non-agency RMBS, including,

- Loan-level data on 97 percent of active non-agency securitized mortgages (over $1.4 trillion)
- More than 98 percent of the jumbo mortgage pools
- More than 93 percent of the asset-backed securities (ABS) market
- More than 12,000 active private-issue securities
- History back to 1991[14]

Figure 6 illustrates that each subsequent vintage quarter demonstrates a more accelerated development than the previous vintage from VY2005-Q1 to VY2006-Q4. The calendar-year effect of the credit crisis impacted each vintage adversely, and this is shown by ever steeper loss development curves.

Figure 6: Cumulative Loss Rate Development by Vintage Quarter



Source: Milliman, LoanPerformance mortgage securities data

2.3 Practitioner Use of Development-Type Projections

Many practitioners, including the authors, have deployed development-type methods, so it is critical to understand the limitations of such methods as discussed above.

For example, Moody's Investors Service (Moody's) "provides credit ratings and research covering debt instruments and securities."[15] In addition, Moody's RMBS Group is a "source of credit ratings and research for Jumbo MBS and Mortgage-Related ABS including home equity and manufactured housing. Asset classes include: prime mortgages, subprime mortgages, home equity loans, net interest margins, manufactured housing, and residential mortgage servicers."[16]

As of April 2010, Moody's had nearly 7,200 outstanding deals rated, corresponding to $5.5 trillion of original loan balance for RMBS asset classes worldwide. For U.S. deals, the numbers were almost 6,000 deals, corresponding to $3.4 trillion. Figure 7 summarizes the deal counts for Moody's by region and RMBS asset class and shows original loan balance on outstanding deals rated by region.

Figure 7: Summary of Moody's RMBS Ratings Coverage by Collateral and Geography

RMBS						
	US	**EMEA**	**Asia-Pacific**	**Non-US Amer**	**Global**	
HOME EQ/US	768				768	
SUBPRIME/US	2,007				2,007	
ALT-A/US	1,853				1,853	
PRIME/US	911				911	
EMEA		594			594	
ASIA PACIFIC			316		316	
AMERICAS				68	68	
OTHER	446	158	59	4	667	
RMBS TOTALS	5,985	752	375	72	7,184	deals
	$3,436	$1,704	$360	$12	$5,511	US $bill, orig balance

Source: Moody's Investor Service, Structured Finance Quick Look, 12 April 2010.

An integral part of providing credit ratings of RMBS is the ability to forecast mortgage collateral credit losses. Collateral credit losses directly affect RMBS investor cash flow obligations, the ability of the RMBS to make timely payments of principal and interest, and therefore, RMBS credit ratings.

As of September 2008, Moody's approach to projecting mortgage collateral credit loss appears to have included loss development-based techniques, among other methods.[17]

Moody's loss-curve-based loss projection for each pool (i.e., cohort of loans) consisted of three components:

(1) The pool's realized cumulative losses to date.

(2) The projected losses for the next 18 months associated with loans that are currently delinquent (the "pipeline" losses).

(3) The projected "future losses" on loans that are not currently delinquent, plus the projected losses beyond the next 18 months associated with loans that are currently delinquent.

Moody's approach to projecting ultimate loss rested more or less on an approach akin to the incurred loss development technique[18] with slight tweaks but still readily identifiable as analogous to an incurred loss development technique. Item (1) above is the same as cumulative paid losses where the paid loss data is organized as a cumulative paid loss triangle with vintage quarters in one column to the left and cumulative paid loss development since vintage reading from left to right. Figure 8 presents a vintage cumulative paid loss development triangle but without specific numbers, which is due to limitations of distribution.

Figure 8: Illustrative Vintage Cumulative Paid Loss Development Triangle

Cumulative Paid Losses										
	Development Since Vintage									
Vintage	1	2	3	4	5	6	7	8	9	10
1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	
3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX		
4	XXX	XXX	XXX	XXX	XXX	XXX	XXX			
5	XXX	XXX	XXX	XXX	XXX	XXX				
6	XXX	XXX	XXX	XXX	XXX					
7	XXX	XXX	XXX	XXX						
8	XXX	XXX	XXX							
9	XXX	XXX								
10	XXX									

Item (2) is comparable to case reserves. In fact, mortgage guaranty insurers establish reserves for delinquent loans—however, not only for the next 18 months of payments on delinquent loans. Delinquency is considered to be the occurrence for purposes of accruing a loss reserve.[19]

The sum of Items (1) and (2) is essentially cumulative incurred losses. In order to derive a loss curve that is essentially the incurred loss curve, the paid loss curve is chosen and accelerated 18 months. Loss curve refers to "the expected percentage of a pool's ultimate losses that will be realized at a given point in the life of the pool."[20]

In other words, loss curve is the reciprocal of cumulative loss development factors. It is not clear how Moody's derived their paid loss curve, but one can be derived from the cumulative loss development factors.[21] The paid loss curve is accelerated 18 months and is meant to represent the incurred loss curve with the assumption that the amounts derived in Item (2) above will be paid within 18 months of the evaluation.

Given the challenges involved with analyzing mortgage guaranty insurance loss data and the importance of path dependence,[22] Moody's does offer a solution for easing data handling, but this segregation of case reserves between those associated with defaults in the next 18 months and those beyond would not be consistent with mortgage insurance accounting.

In order to project ultimate losses on loans that are not currently delinquent, plus the projected losses beyond the next 18 months associated with loans that are currently delinquent, the sum of Items (1) and (2) (i.e., essentially cumulative incurred losses) is divided by the corresponding incurred loss curve. Item (3) is then calculated as the difference of the quotient minus the sum of Items (1) and (2).

The remaining difference between Moody's approach and the loss development technique of actuaries was one of terminology. Actuaries refer to the approach as the "loss development

technique," whereas structured finance practitioners refer to it as the "loss curve-based loss projection." Actuaries rely on cumulative loss development factors and take the product of cumulative loss times cumulative loss development factors to calculate ultimate loss, while structured finance practitioners take the quotient of cumulative loss divided by the loss curve to calculate lifetime cumulative loss. The loss curve is comparable to the reciprocal of a cumulative loss development factor.

It is worth noting that Moody's has introduced a loss methodology relying on not only a loss development technique, but also on underwriting characteristics and economic projections. Moody's loss methodology can be broken down into five steps (the paper cites four steps, but there appear to be five listed).[23] The loss methodology for first lien subprime RMBS is summarized in the following steps:

Step 1: Delinquency projection to near-term distress period.

Step 2: Calculating the rate of new delinquencies.

Step 3: Calculating future delinquencies after near-term distress period.

Step 4: Calculating losses from delinquencies.

Step 5: Modification adjustment.

Step 1 is a mix of both development and collateral-based projection methods, the latter being a regression model based on key loan-level credit characteristics and economic forecasts. However, Steps 2 and 3 rely fundamentally on the development technique. Step 2 notes,

> To forecast future defaults after the near-term distress period, we first calculate the rate of new delinquencies that occurs during the near-term distress period… The rate of new delinquencies is the annual change in serious delinquencies during the near-term distress period divided by the balance of loans that are contractually current or 30 days delinquent at the beginning of the near-term distress period.

Step 3 continues, "Project additional annual delinquencies for seven years after the near-term distress period, by decelerating the rate of new delinquencies calculated in Step 2 to reflect the expected incremental improvement in future economic and housing conditions." The component of Step 2 is derived using both development and collateral-based projection methods, the components of Step 3 are derived by changes in the component of Step 2, basically a development approach. Step 4 leverages frequency projections from Steps 1 through 3 and severity estimates to calculate loss amounts, while Step 5 acknowledges major mortgage industry reform aiming to curb mortgage

credit losses; programs such as Home Affordable Modification Program (HAMP), principal write-down, foreclosure moratorium, etc.

There are other examples of practitioners referring to the loss development methods in connection with mortgage credit risk analysis. In *Subprime Mortgage Credit Derivatives*,[24] the authors advocate a pseudo-incurred loss development method similar to Moody's described above. They recognize econometric/statistical models for forecasting mortgage collateral credit loss, but focus their description of a methodology fully on the pseudo-incurred loss development method, termed an "autopilot model" because it is "more straightforward; it is completely transparent, with no hidden assumptions," replicable, and driven by loss performance.

The autopilot model is summarized in five steps:

Step 1: Convert 60-, 90+-days delinquent and bankruptcy loans to pipeline default.

Step 2: Calculate the default pipeline as percent of the current balance.

Step 3: Calculate the total default as a percent of the original balance.

Step 4: Project the cumulative default from default timing curve and total default.

Step 5: Project the cumulative loss.

The autopilot model is similar to Moody's loss curve projection model except for some subtle difference and terminology. The case reserve portion for Fabozzi and his team represents projected lifetime losses (not just for the next 18 months) for loans that are currently delinquent. The loss curve is accelerated an amount of time consistent with the average transition time from delinquent to default. Nevertheless, this approach is a development method. However, Fabozzi's team appears to advocate reviewing indications of assumptions by homogeneous key economic assumptions, particularly home price appreciation (more on that below).

There are also examples of investors holding non-agency RMBS that appear to be utilizing loss development techniques for valuing mortgage collateral underlying RMBS. According to their Sept. 30, 2009, SEC 10Q, Old National Bancorp (ONB) owns non-agency RMBS with a market value of $184 million. There is not enough text to draw conclusions with certainty about the robustness of their loss methodology, but the excerpt below leads us to believe that ONB relies on a loss development technique with assumptions based on limited risk segmentation of loan-to-value (LTV), property location, and loan status (i.e., healthy vs. seriousness of delinquency):

> …a detailed analysis of deal-specific data was obtained from remittance reports provided by the trustee and data from the servicer. The collateral was broken down into several distinct buckets based on loan performance characteristics in order to apply different assumptions to each bucket. The most significant drivers affecting loan performance were examined including original loan-to-value ('LTV'), underlying property location and the loan status. The loans in the current status bucket were further divided based on their original LTV: a high-LTV and a low-LTV group to which different default curves and severity percentages were applied. The high-LTV group was further bifurcated into loans originated in high-risk states and all other states and a higher default-curve and severity percentages were applied to loans originated in the high-risk states. Different default curves and severity rates were applied to the remaining non-current collateral buckets.

The authors have also utilized loss development techniques for analyzing mortgage credit risk, as well as other methods. In doing so, we have gained an appreciation for techniques that can augment such analyses in light of the limitations discussed above.

2.4 Some Suggestions for Practitioners in Coping with the Development Method Limitations

The loss development technique is a method that's easy to use and should be considered when performing mortgage credit loss analysis, but generally should not be relied upon solely. Other approaches that should be considered include econometric models, Bornhuetter-Ferguson (B-F),[25] Berquist-Sherman,[26] and Barnett-Zehnwirth.[27]

For example, we suggest that one approach for estimating future mortgage credit losses in light of the considerations we have outlined is to include not only the development techniques, but also B-F methods and econometric models with suitable adjustments. The keys to the B-F method are a priori estimation of loss and loss emergence patterns. The loss pattern can be derived from the loss development factors of appropriate mortgage pools with any adjustments that the practitioner deems appropriate in light of economic conditions. The a priori is based on the ultimate loss estimates derived from the proposed econometric technique coupled with a loan-level assessment of the underwriting characteristics of the subject loan pool.

B-F techniques can be particularly valuable to provide a more stable estimate of ultimate loss rates in situations where loss development is volatile, substantial, and/or immature, and yet, provide a forecast that is responsive to economic conditions by grounding the a priori indication to economic conditions and forecasts. The B-F approach is particularly useful for mortgage credit loss projections because of the long-term nature of the risk and its ability to blend the unfolding loss

development experience with a forecast of future loss development that is responsive to the underwriting characteristics of the loans remaining in the collateral pool along with economic risks to which those loans are exposed.

For example, the practitioner has the ability to adjust the forecasted losses for changes in persistency rate of the cohort of loans and changes in the nature of the risks as the run-off of terminated loans changes the risk profile of the block of loans remaining in the collateral pool. Specifically, the analyst can adjust the a priori ultimate claim or loss rate utilized to project future loss emergence in order to better reflect the faster-/slower-than-expected terminations of loans and changes in book risk profile for recent years, as well as biases that can exist in the loans that remain compared to those that terminate. This suggests two important adjustments:

(1) The exposure duration for mortgages can vary significantly depending on termination rates. During periods of robust growth in credit availability and increasing home prices, subprime mortgages pre-paid at rapid rates. This had the effect of accelerating the loss emergence curve (LDF pattern) and decreasing the ultimate level of losses due to shorter exposure to default losses. After the crisis, the voluntary pre-payment rate (i.e., excluding defaults) on subprime mortgages has plummeted and this has lead to a longer exposure to loss and a greater exposure to loss. This might suggest a corresponding adjustment to the length and shape of the emergence curve, as well as the a priori default rate or loss rate.

(2) The B-F is concerned with forecasting future default losses indicative of the underwriting characteristics of loans that remain in the collateral pool, as well as the economic environment to which those loans will be exposed. This highlights the importance of re-selecting an a priori rate that reflects the underwriting characteristics of the remaining pool and the forecasted future economic environment. Importantly, there tends to be a negative bias in the quality of loans that remain after loans voluntarily terminate from refinancing activity. When changes in the nature of these voluntary pre-payments occur, this can cause significant distortions that should be considered.

Thus, the econometric types of approaches to establishing the a priori default rate or loss rate should consider loan-level collateral characteristics, aggregate portfolio persistency, and forecasts of key economic variables.

There are a host of loan-level collateral characteristics available to the actuary for calibrating a regression model. The underwriting characteristics can be categorized as those relating to the

borrower, loan, and property. Fabozzi et al. identify characteristics to consider for collateral-based modeling: borrower FICO, LTV, documentation type, loan purpose, and loan size. Dihora, Mrotek, and Schmitz identify the variables borrower FICO, LTV, presence of interest-only or negative amortization option, loan purpose, property type, occupancy, documentation, loan size, and amortization.[28] Moody's updated loss methodology incorporating collateral-based projection relies on the following characteristics: loan type (fixed/adjustable), purpose, occupancy status, property type, vintage, origination FICO score, loan amortization (interest-only or principal-and-interest), loan origination, and updated LTV ratios. FitchRatings variables are credit score, credit sector, LTV, documentation type, property type, product type, loan term, prepayment penalty, occupancy, debt-to-income ratio (DTI), loan balance, and loan purpose.[29]

Needless to say, there are many other publications available addressing loan-level characteristics to consider for mortgage credit loss modeling. Oftentimes, the analyst is limited to using characteristics represented in the data set. Havlicek/Mrotek reviewed the LoanPerformance mortgage securities data set, for example, where all underwriting fields deemed to be well populated were found to be statistically significant.[30] These fields were LTV, FICO, interest rate delta, loan product, property type, loan purpose, foreclosure type in state, loan term, documentation type, lien position, presence of negative amortization feature, occupancy, prepay penalty, and loan size.

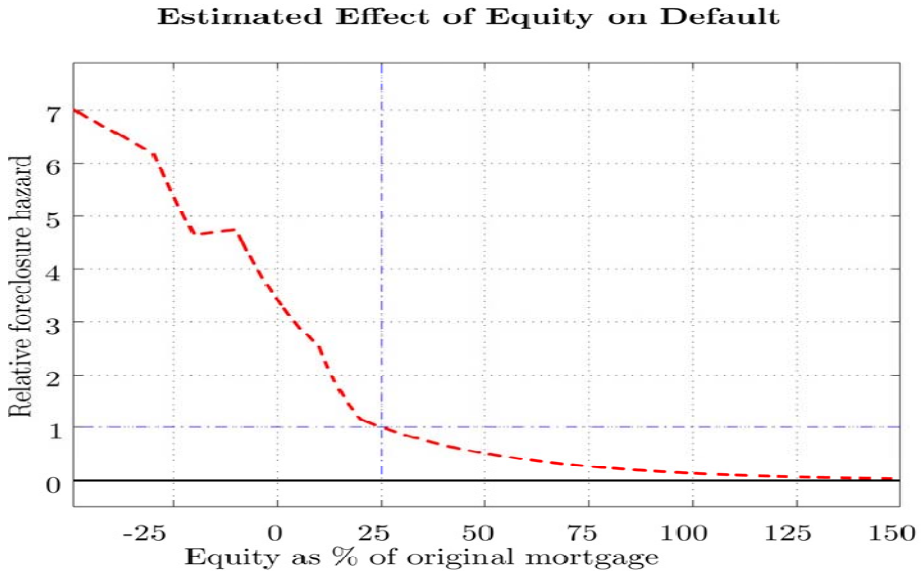
In addition to underwriting attributes, it is critical to include forecasts of key economic variables. Three economic variables often mentioned when modeling mortgage credit losses are home price appreciation, unemployment, and interest rates.

Home price appreciation is the most critical of the economic forecasts. Laurie Goodman, co-author of "Negative Equity Trumps Unemployment in Predicting Defaults," in testimony to Congress about her paper said, "The evidence is irrefutable. Negative equity is the most important predictor of default."[31]

Figure 9 charts the relative foreclosure hazard (y-axis) as a function of equity as a proportion of the original mortgage (x-axis). The independent variable in this chart is more or less the aggregate result of combining original LTV, home price appreciation (HPA) from origination through evaluation, and principal payments. Original LTV is addressed in the underwriting attributes and relative principal payments in the peak loss years tend to be small, which indicates that HPA is a major driver. When a borrower has 25% or more equity in their property, the relative foreclosure hazard is relatively inelastic. Basically, there tends to be enough equity to insulate the lender from

loss because the borrower's equity acts as a buffer against first loss. But as equity declines from 25% to negative equity, relative foreclosure hazard increases markedly.

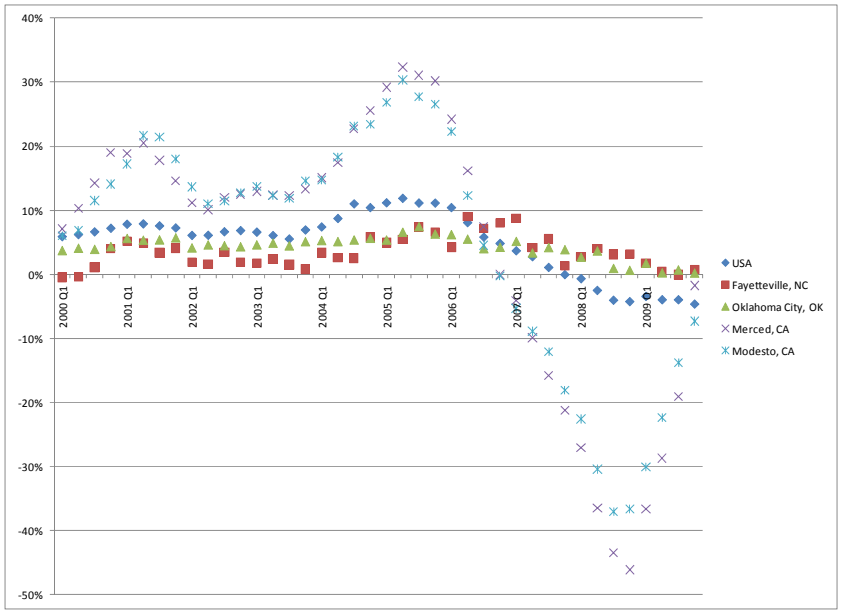
Figure 9: Estimated Effect of Equity on Default



Source: Foote et al., "Negative Equity and Foreclosure: Theory and Evidence."[32]

When considering home prices forecasts, it is important to rely on those at the most granular level available. Home prices vary significantly by region. There are nearly 400 metropolitan statistical areas in the United States.[33] For properties not in metropolitan areas, the home prices of the state can act as a substitute. Figure 10 illustrates the Federal Housing Finance Agency (FHFA) variations in home prices by four different metropolitan areas against the aggregate of the United States. It highlights the variation between geographical regions, particularly that while some regions are experiencing modest increases of a few points per year, others can experience double-digit changes, either positively or negatively. This difference in underlying economics can lead to materially different mortgage credit performance. Note that these changes in home price are for the 12 months leading up to the evaluation date. For example, the 32% annual home price appreciation for Merced, Calif., as of 2005-Q2 was for the 12 months July 2004 through June 2005.

Figure 10: FHFA Changes in Home Price Indices by Selected Metropolitan Area and U.S.



Source: Milliman, FHFA All-Transactions Indexes through 2009-Q4

Forecasts of home prices by metropolitan area, state, or just the United States, can be purchased from economists or internally developed and incorporated into mortgage credit loss projections. The forecasts from economists tend to be released quarterly and the future periods are also quarterly. Two providers of this data include Moody's Economy.com and Global Insight. Several trade groups publish forecasts of home prices, but the level of granularity is much more limited, typically only covering large geographies and limited time periods. The Mortgage Bankers Association, National Association of Realtors, and *Wall Street Journal* surveys of economists are free sources.

Unemployment is another variable to consider. Moody's identifies change in unemployment rates over a six-month period as an input into their modeling.[34] For obvious reasons, common sense suggests unemployment might be a predictor of mortgage credit losses. Borrowers without jobs and income, all things being equal, will have more difficulty making mortgage payments and therefore heading down the path to default. However, whereas home price appreciation tends to have a macro impact on house prices and therefore borrower equity, unemployment tends to be more binary. Borrowers are either employed or unemployed (admittedly, this can be a definition with gray areas such as underemployment).

Several studies indicate that unemployment is not a statistically significant predictor of mortgage credit losses. The Mortgage Insurance (MMI) actuarial report of the Federal Housing Administration (FHA) for fiscal year 2007[35] cites a weak link between unemployment and mortgage credit losses:

> As described in the FY 2006 Review, we previously undertook to develop a measure of changes in metropolitan area unemployment rates. Data on metropolitan area unemployment rates were obtained from the Bureau of Labor Statistics and converted into times series from which we computed a dynamic measure for the percentage change in the unemployment rate over the preceding year. The unemployment rate variables did not perform well in any of the preliminary models that were estimated, and have not been included in the final model specifications. No consistent pattern was observed between mortgage claims and increases in local area unemployment rates, in contrast to the strong relationship between loan performance and borrower equity. This outcome is consistent with prior experience using this variable in loan-level models in which borrower behavior is more strongly linked to changes in the borrower's equity position or changes in the value of the mortgage instrument due to changes in interest rates. Changes in these variables have a direct impact on property and mortgage values, whereas the local area unemployment measure has a much weaker connection to individual borrowers.

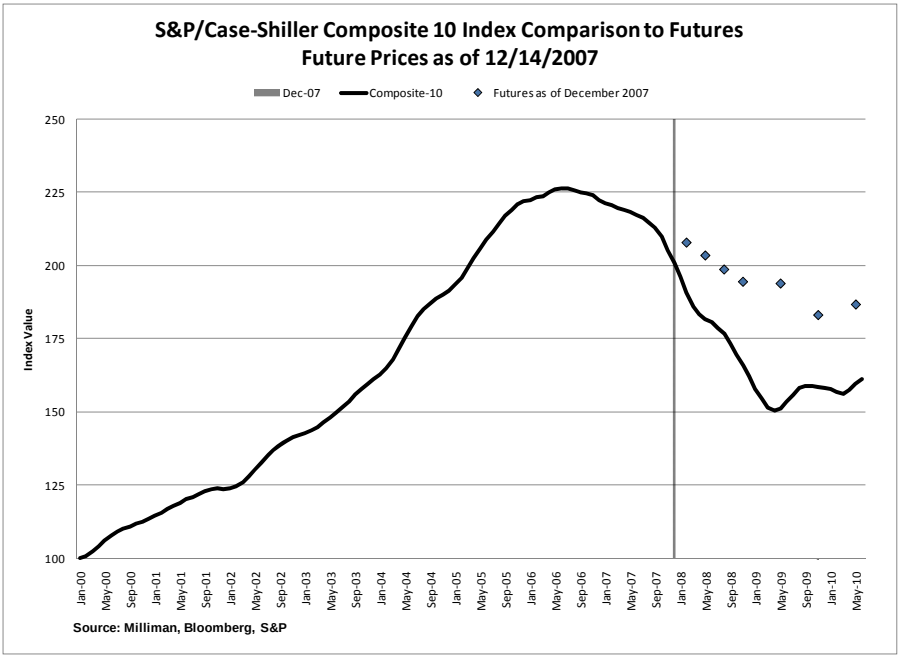
Laurie Goodman, in her testimony to Congress, also speaks of unemployment's role in predicting mortgage defaults, saying, "If a borrower has positive equity, unemployment plays a negligible role. We found that all borrowers with positive equity performed similarly no matter the local level of unemployment."[36]

Therefore, HPA tends to receive more attention when forecasting mortgage credit losses. The implications of the relationship between foreclosure and negative equity illustrated in Figure 9 suggest the highlighted importance of reflecting home price appreciation or depreciation in calibrating mortgage credit risk models. When home price appreciation is strongly positive, as it was leading up to the peak in 2006, borrowers from the early 2000s with even small down payments (i.e., high loan-to-value (LTV) ratios) quickly found themselves with significant positive equity, which permitted them to refinance or at least took them down into the relatively inelastic portion of the graph above where relative foreclosure hazard is low. On the other hand, when home prices began to drop in late 2006, many borrowers with higher LTV ratios who took out loans near the top of the market found that their equity evaporated quickly and then turned markedly negative, and this had a dramatic effect on default risk as borrowers slid up the graph on Figure 9 toward the higher hazard multiples.

Econometric modeling should thus pay keen consideration to home price changes for forecasting mortgage credit losses. The original LTV ratio establishes an estimate of starting equity position. Beyond that point in time, it can be valuable to incorporate an estimate of the change in home price since loan inception. This can be accomplished using the changes in home price indices from loan inception to current evaluation date and then augment this with a forecast of future price changes over the default loss forecast horizon. Ideally, this should be done at the loan level, using as granular an estimate of home price changes since inception as possible.

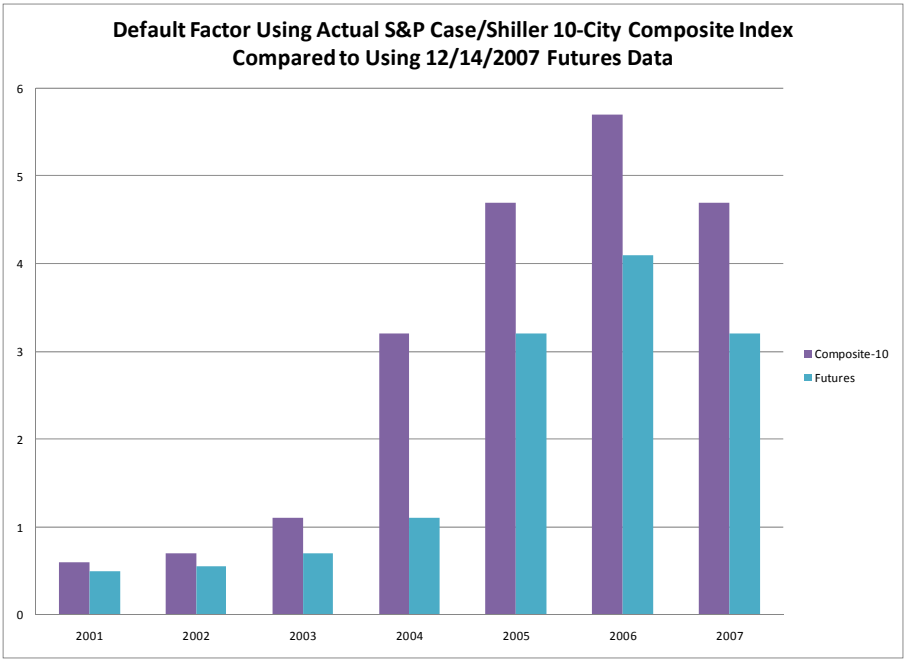
However, a simple illustration of this relationship is instructive based on the implied average equity position derived from using the starting LTV ratio for the composite average subprime vintages, as illustrated in Figure 3. We take these average LTV ratios by vintage as the starting equity position and then adjust for price changes implied by the S&P Case-Shiller 10-city composite index since loan origination (i.e., ignoring amortization and assuming uniform loan originations during the vintage year). Figure 11 shows the home price path for the 10-city composite index. The actual change in the 10-city index is shown along with the futures values implicit forecast valued at December 2007. It is interesting to look at these contrasting paths, since the futures values can serve as one barometer of forecasted price changes that might have been used by a practitioner at the end of 2007, while the actual index path can show the resulting forecast with perfect knowledge of home price changes for the index.

Figure 11: S&P/Case Shiller Composite 10 City Index, CME Futures and Actual



As seen in Figure 11, the home price depreciation from peak to trough was considerably more severe than that suggested by the futures values as of December 2007. Specifically, the peak to trough drop in the actual index from the graph is approximately 34%, while the December 2007 futures values suggested an approximate 19% peak to trough decline. This suggests that the default rates projected using the actual home price changes will certainly be higher. We estimate the equity position at the bottom of the market implied for the average combined LTV from Figure 3 adjusted for the change in home prices since inception. Based on these average equity position proxies, Figure 12 compares relative default rate multipliers using the relative foreclosure hazard relativities from Figure 9 (the base of 1.0 for this graph is identical to that from Figure 9, which represents 25% equity, or an LTV of 75%).

Figure 12: Default Factor Using Actual Index Versus Futures



Clearly, there is a high degree difference in mortgage credit risk propensity by vintage due to economic factors alone at the bottom of the house market, as suggested by this exercise. Furthermore, the deeper actual index declines to trough relative to those suggested by the futures values at December 2007 lead to a significantly higher default rate multiplier. This illustration simply represents the relative default propensity at the trough, though the practitioner may be interested in the relative propensity over the forecast horizon when calibrating the a priori default or loss rate for the B-F method. Despite the over-simplicity of this illustration, it is indicative of the strong impact that home price changes can have on default propensity, and thus, the importance of consideration in this type of analysis.

3. Conclusion

The increased attention on independent mortgage credit risk analysis represents an opportunity for actuaries knowledgeable in this area. As actuaries, we often consider loss development techniques to be a valuable tool and some practitioners rely at least in part on these methods for projecting mortgage credit losses. When doing so, it is critically important to consider the characteristics of mortgage loans and the economic conditions to which the loans are exposed. As

casualty actuaries are aware, the LDF method has inherent limitations associated with immature development. Methods relied on for projecting mortgage credit losses should properly consider loan-level underwriting characteristics related to the borrower, property, and loan, and to key economic variables. As one example, B-F methods can be adapted to reflect these considerations.

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[Note: One subtle difference between Moody's provision for pipeline losses and insurance case reserves is that Moody's pipeline losses are for defaults in the next 18 months, associated with currently delinquent loans, whereas insurance case reserves are losses associated with currently delinquent loans that remain delinquent continuously until default. Put differently, losses on defaults in the next 18 months associated with currently delinquent loans that will become healthy (i.e., not delinquent), then go delinquent again later on and eventually default within 18 months should not be reflected in case reserves on currently delinquent loans (in mortgage insurance). But this amount

would be accounted for in Moody's pipeline losses.]
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Tail Risk, Systemic Risk and Copulas

Andy Staudt, FCAS, MAAA

Abstract: Copulas are an elegant mathematical tool for decoupling a joint distribution into the marginal component and the dependence structure component; thus enabling us to model simultaneous events with a greater degree of flexibility. However, as with many statistical techniques, the application of copulas in practice is as much art as it is science. And risk management considerations, such as the increased focus on tail events over central moments, should drive selections of copulas just as much as statistical goodness-of-fit analysis. This paper focuses on several modeling considerations when working with copulas from the perspective of adequately accounting for the behavior in the extreme tails of both the marginal and joint distributions.

Keywords. Copulas; tail risk; systemic risk; joint loss distributions.

1. INTRODUCTION

There is all too often a tendency to focus on what is *reasonably possible* at the expense of what is *remotely probable*. Prospect Theory, pioneered by Daniel Kahneman[1] and Amos Tversky, argues that individuals conflate negligibly or near-zero probabilities with zero probability. When there is a sufficiently remote chance of an event occurring, say 0.01%, most will dismiss this event as even a possibility. However, these remote events are not only likely, but often their likelihood is understated due to a limited understanding of these increasingly small numbers (i.e., what in actuality constitutes a 1-in-10,000 year event when we only have several hundred years of data from which to draw conclusions). And while it may be human nature to ignore such remote probabilities, it is exactly this type of mistake which we, in a risk management context, can not afford to make; as it is these negligible events which can make, or more importantly break, a company. Not only is it essential that we concern ourselves with these unlikely events in isolation, or tail risk, but it is becoming increasingly evident that we also concern ourselves with these unlikely events in tandem, or systemic risk. As the recent financial crisis illustrates, tail and systemic risk are very real and very devastating.

It is now apparent that a major shortcoming in many of the models underlying our financial system is that they failed to adequately comprehend, or just ignored, the risk in extreme events. While it is increasingly in vogue to dismiss many of these models out of pocket, we would argue that it is not the mathematics which are inherently flawed, rather it is the assumptions and simplifications made when implementing such models which are flawed.

[1] Kahneman won the Nobel Prize in Economics in 2002 for his work in this area.

As an illustration, we specifically look at one such model – the copula. The copula is a mathematical tool for modeling the joint distribution of simultaneous events. From the perspective of tail and systemic risk, the copula is interesting in that it allows us to decouple the marginal distribution (that which is associated with tail risk) from the dependence structure (that which is associated with systemic risk) and model each separately with a greater degree of precision. Greater precision, however, does not necessarily ensure greater accuracy. And many copulas, the normal in particular, are unsuitable for modeling extreme behavior. This paper describes several of the considerations in modeling joint behavior with copulas focusing on delineating the choices which will most appropriately reflect the underlying tail and systemic risk – and consequently, the decisions we make.

1.1 Objective & Outline

This paper covers the following areas:

- *Correlation.* Because correlation is easily distorted by outliers and nonlinearities, it may lead to the incorrect calibration of certain copula structures which ultimately impact our measures of risk. Furthermore, because correlation does not provide a roadmap to a unique copula, it may lead to the selection of a copula which does not adequately allow for large losses.
- *Marginal distributions.* Many marginal distributions do not adequately capture the probability of extreme 1-in-*n* year losses and as such understate tail risk. But not only this, misspecifying the marginal distribution may also cause the copula structure to be misspecified, leading to understated systemic risk.
- *Tail dependence.* Tail dependence is a measure of the dependence between two risks in the tail of their joint distribution (i.e., the probability that two companies simultaneously default). To this end, tail dependence can be thought of as a proxy for systemic risk. However, many copula structures do not allow for this type of dependence and as such understate the probability of simultaneous extreme events.
- *(A)symmetry.* While symmetry is common in theoretics, it is rare in nature. However, many of the most popular copulas are symmetric and thus unable to account for the skew associated with many risky, real world events. Asymmetric copulas, on the other hand, do a much better job of modeling these simultaneous extreme events in either or both tails.

Each self-contained section follows roughly the same structure. We first introduce the topic and explain how it relates to tail or systemic risk. We then present an example which uses actual data in topical risk management situations to illustrate the effect certain assumptions have on ultimate measures of risk. Using objective goodness-of-fit criteria, we show that the more conservative models often provide the best fit. Finally, we end each section by offering a general rule of thumb

for working with copulas.

1.2 Background & Research Context

Simply put, a copula is a mathematical tool for modeling the dependence structure of a multivariate distribution separate from the marginal distribution without having to explicitly specify a unified, traditional joint distribution. Essentially, copula mathematics are a magnifying glass which allow us to analyze and model with greater precision the dependence relationships between associated random variables. This flexibility means that greater emphasis can be placed on the idiosyncrasies of multivariate distributions, especially with respect to behavior in the extreme tails, leading to models which more accurately account for the entire distribution rather than just the central moments.

In actuarial science, copulas have been used for a variety of purposes including simultaneously modeling loss and allocated loss adjustment expense (ALAE) amounts, measuring the benefit of diversification to multiline insurance products, estimating the default risk of a portfolio of reinsurance receivables, and allocating economic capital by line of business. The following contains practical examples of copulas within a variety of these contexts as a means of illustrating how copula specifications can alter our understanding of risk especially with regards to extreme tail behavior.

There is no shortage of research on copulas, as is true with most mathematics tightly linked with financial markets. The bibliography of this paper is divided into four sections: literature on copulas in actuarial science, survey literature on copulas, computer packages for modeling with copulas, and more esoteric topics with regards to copulas. The purpose of the reference section is to direct the interested reader to literature most relevant for a given purpose.

2. CORRELATION

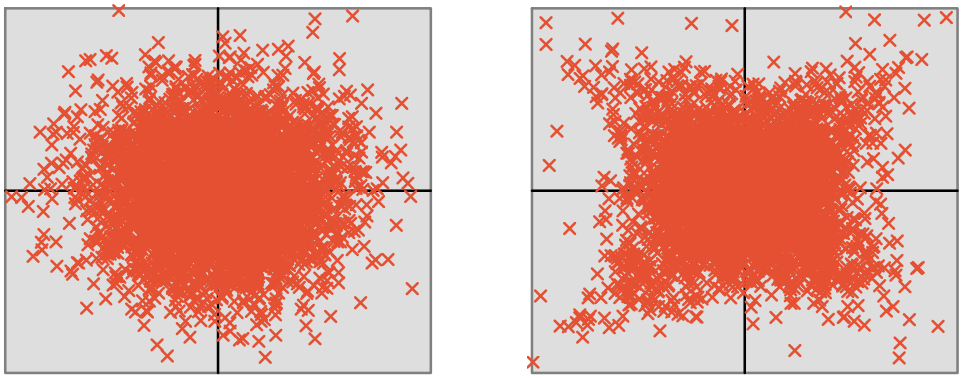
Correlation, as measured by the Pearson correlation coefficient, has increasingly become a proxy for expressing dependence.[2] In some situations this is appropriate, however, more often, correlation is used in a manner which is inconsistent with its actual meaning. This section explores these situations. First, we detail two problems with correlation as a measure of dependence, namely that (1) it does not necessarily uniquely define the joint distribution and (2) it is distorted by outliers and nonlinearities. Next we present an example which illustrates the consequences of using correlation to specify and calibrate the copula structure.

[2] Forthwith, "correlation" refers to Pearson's linear correlation coefficient *rho*.

2.1 The Relationship between the Assumption and the Risk

2.1.1 Correlation does not [necessarily] uniquely define the joint distribution

A classic result in statistics states that independence implies zero correlation, but that zero correlation does not necessarily imply independence (normality is also needed). Even without exploring the meaning of this statement, the logic indicates the problem with correlation—correlation is a weak supposition. Just by virtue of knowing the correlation, we really do not know that much. And thus, it becomes dangerous to assume that by knowing the *correlation*, we truly understand the *dependence* between risks. More specifically, the implication for modeling joint distributions with copulas is that correlation does not necessarily uniquely define the multivariate distribution.



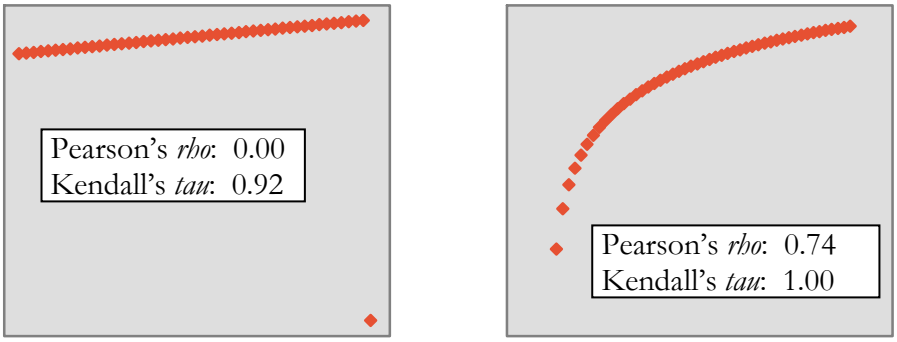
(a) Normal copula (b) *t* copula

Figure 1. Scatterplots of bivariate data generated assuming zero correlation.

Consider Figure 1, based on a similar exposition in Embrechts et al. [20], which compares values simulated from two separate joint distributions. Figure 1(a) shows values which were simulated from a distribution specified by a normal copula and Figure 1(b) shows values which were simulated from a distribution specified by a *t* copula. In both examples, the correlation coefficient is zero. However, this lack of correlation does not necessarily imply that the data is independent. Only the data in Figure 1(a), simulated using a normal copula, is independent. The data in Figure 1(b), simulated using a *t* copula, is in fact dependent. Specifically, there is positive dependence in the tails of the distribution which is not only evident in the grouping of data points in the upper-right and lower-left corners, but can be derived mathematically (and will be in later sections for other purposes). This tail dependence implies that, everything else being equal, the *t* copula might be better suited for modeling joint behavior in situations where systemic risk is of a real concern.

2.1.2 Correlation is easily distorted

Pearson's linear correlation measure is not robust to outliers and because it is a measure of *linear* association it often fails to comprehend the full dependence found in *nonlinear* relationships. As an alternative, rank correlation measures, such as Kendall's *tau* and Spearman's *rho*, are more suitably robust to outliers and, because they operate on ranks of the data rather than nominal values, can both capture nonlinear relationships and are invariant to certain transformations such as the natural logarithm (a very useful technique in modeling probabilities). Furthermore, rank correlations actually have a natural place in copula mathematics, however this is beyond the scope of the paper.



(a) Outliers (b) Nonlinear relationships

Figure 2. Weaknesses in the linear correlation measure.

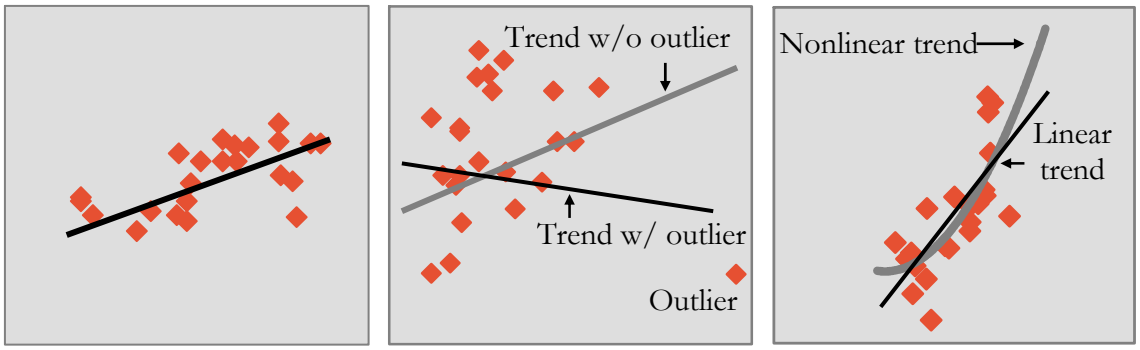
Figure 2 illustrates these weaknesses. In Figure 2(a), the single outlier in the bottom right completely distorts Pearson's correlation measure while only slightly distorting Kendall's measure of association. In Figure 2(b), the data is generated by an exact, albeit nonlinear, relationship and because Pearson correlation is a measure of linear association it does not recognize the perfect relationship whereas Kendall's *tau* does. In both these examples, Pearson correlation would lead to significantly understated estimates of risk.

Now, *if* we know that the copula describing the joint distribution is either normal or *t*, we can parameterize the copula using either empirical estimates of correlation or empirical estimates of Kendall's *tau*. However, as Figure 2 indicates, it is likely that the empirical estimates of correlation will be distorted by outliers or nonlinearities or both, and thus will not be appropriate to modeling joint relationships.

2.2 An Illustration

The following example uses historical loss ratios for the period from 1986 through 2008 as compiled by the Texas Department of Insurance (TXDOI) for the following lines of business—general liability (GL), commercial automobile liability (CAL), commercial multiple peril-property

(CMP-Property), and commercial multiple peril-liability (CMP-Liability). In order to illustrate the concepts in section 2.1, we calculate the risk for the combined book of business as well as the capital allocation implied by each of several copula structures. Specifically, we compare a normal copula parameterized with correlation, to a *t* copula parameterized with correlation and to a *t* copula parameterized with Kendall's *tau*. In this situation, the first copula does not adequately account for the presence of systemic risk in the data and both the first and second copulas are distorted because the correlation measure is distorted both by outliers and nonlinearities.



(a) GL by CAL (b) CMP-Property by GL (c) CAL by CMP-Liability

Figure 3. Scatter-plots of loss ratios by line of business.

Figure 3 plots various combinations of these historical loss ratios. The reference trendlines are included to provide a general indication of the correlation (i.e., positive-sloped trendlines have positive correlation, flat trendlines have no correlation and negative-sloped trendlines have negative correlation). From Figure 3(a) it would appear that linear correlation is indeed appropriate for measuring the positive dependence between GL and CAL. However, the correlation statistic between CMP-Property and GL is distorted by the outlier in Figure 3(b); and Figure 3(c) shows evidence of a nonlinear relationship. In both these cases, the correlation measure inadequately expresses the dependence structure, understating the risk.

If we assume that the dependence between these lines of business can be modeled by an elliptical copula, either normal or *t*, then it is possible to quantify the extent to which correlation misspecifies the dependence between lines. Specifically, in the elliptical family of copulas the relationship between Kendall's *tau* and Pearson's correlation *rho* is given as $\varrho=\sin(\pi\tau/2)$. Table 1 compares the correlation implied by Kendall's *tau* statistic using the above relationship with the correlation computed manually.[3] Note that the implied correlation between GL and CAL is identical to the actual correlation as indicated in Figure 3(a). However, the correlation between GL and CMP-

[3] The Kendall Implied Correlation is given as $(2/\pi)\sin^{-1}(\varrho)$ where ϱ refers to Pearson correlation.

Property was indeed distorted by the outlier which produced negative correlation even though Figure 3(b) would indicate a positive dependence without that outlier. The correlation between CAL and CMP-Liability is also understated as the correlation does not recognize the slight nonlinear relationship between these two lines (i.e., the CAL loss ratio increases more sharply for large values of the CMP-Liability loss ratio than for small values).

		Dependence Coefficients			
Line A	Line B	Kendall	Kendall Implied Correlation	Correlation	Cause of Distortion
GL	CAL	0.40	0.60	0.60	Not distorted
GL	CMP-Property	0.15	0.25	(0.10)	Outlier
CAL	CMP-Liability	0.60	0.80	0.70	Nonlinearity

Table 1. Comparison of the correlation implied by Kendall's *tau* statistic in an elliptical family of copulas and the correlation calculated manually using Pearson's *rho* statistic.

In order to further quantify this effect, we fit three copulas to this data. The first copula is a normal calibrated with the empirical correlation, the second copula is a *t* calibrated with the empirical correlation and the third copula is a *t* calibrated with the correlation implied by Kendall's *tau*. Note that comparisons between the first and second copula structures will help to illustrate the premise of section 2.1.1, namely that the correlation matrix does not uniquely define the joint distribution. And that comparisons between the second and third copula structures will help to illustrate the premise of section 2.1.2, namely that correlation is easily distorted.

Table 2 shows the Conditional Tail Expectation (CTE) at the 95th percentile of the excess loss ratio by copula structure for all lines of business combined (for simplicity, we assumed equal exposure by line). Also shown is the percentage capital allocation by line implied by the CTE statistic.

				Capital Allocation				Cramer-von-Mises
#	Copula	Calibration	CTE(95th)	CAL	CMP Liability	CMP Property	GL	Goodness of Fit Statistic*
1	Normal	Pearson's *rho*	1.30	28%	35%	12%	25%	0.11
2	*t* (df=8.5)	Pearson's *rho*	1.35	28%	35%	12%	25%	0.11
3	*t* (df=11.0)	Kendall's *tau*	1.50	28%	40%	10%	22%	0.05

*Smaller values indicate a better fit.

Table 2. CTE at the 95th percentile and percentage capital allocation for each copula structure. The degrees of freedom (df) for the *t* copulas are computed using maximum likelihood estimation holding the copula correlation parameters fixed.

When comparing the first and second copula structures, note that while the percentage capital allocation is not distorted by choosing to use a normal copula, the overall risk is understated. The percentage capital allocation for these copulas is not that affected as these two copulas are parameterized using the same correlation matrix. However, the CTE is higher for the *t* copula as there is greater dependence in the tail of the *t* copula than in the tail of the normal copula.

When comparing the second and third copulas note that both the CTE and the percentage allocation are distorted. Here, we see that the higher implied correlation between CAL and CMP-Liability as well as between GL and CMP-Property significantly drives up the CTE. The percentage capital allocation has also changed as the dependence relationships between lines have changed reflecting the shift in relative riskiness.

Finally, not only is the third copula structure the most conservative, it also objectively, as measured using the Cramer-von-Mises statistic[4], provides the best fit and thus the most reliable estimates of the CTE and capital allocation.

2.3 A Good Rule of Thumb

It is important to remember that correlation is only one measure of association (specifically linear dependence) and as such only tells one side of the story. Although it is useful in defining certain dependence structures (i.e., the multivariate normal distribution), it is easily distorted by outliers and nonlinearities, which can affect the calibration of a copula structure; and it does not provide a roadmap to the correct choice of copula. To these ends, other measures of association, such as Kendall's *tau*, should also be considered as they provide additional insight into the dependence structure and are not as easily tricked by outliers and nonlinearities. Furthermore, other considerations, such as the shape of data, expert opinion and outside estimates of risk, must be weighted carefully and included in any calibration and selection of a copula. Dependence is a dynamic concept, and flat representations like correlation, will always lose something in translation.

3. MARGINAL DISTRIBUTIONS

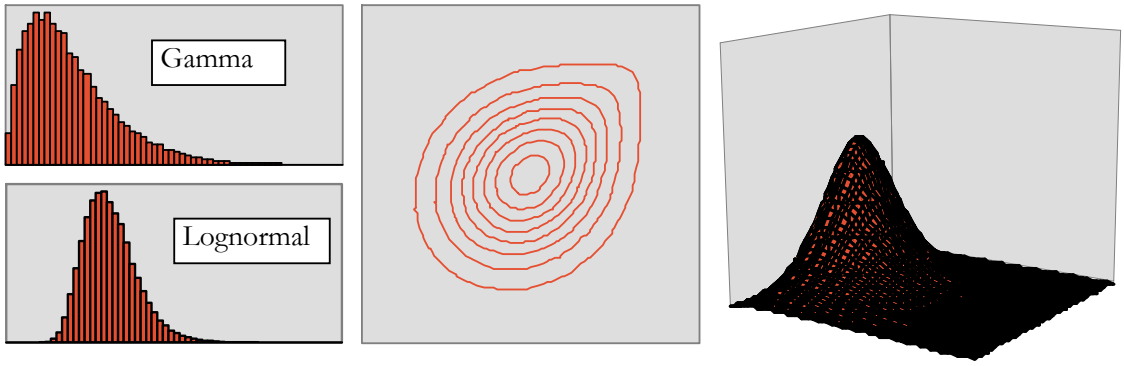
This section explores the separation between the marginal distributions and the dependence structure in copula models. Although copulas allow us to model these components separately, they are by no means independent of one another. Errors in specifying the marginal distributions can

[4] Generally speaking there are a variety of ways to assess and compare the fits of various copulas. However, most commonly used methods, such as the Cramer-von-Mises statistic, rely on computing some measure of the distance between the estimated copula and the empirical copula.

have far-reaching consequences on the copula fit and the final modeled joint distribution. This is especially true when there is significant tail risk. To illustrate this phenomenon, we fit copulas to historic corn and soybean losses where the marginals are estimated using either a gamma distributions, the empirical distribution function or a mixed empirical-generalized Pareto distribution. We then show how the gamma distribution and the empirical distribution function lead to copula parameterizations which understate the systemic risk relative to the mixed generalized Pareto distribution.

3.1 The Relationship between the Assumption and the Risk

Perhaps the major benefit of copulas is that the dependence structure (i.e., the copula) can be decoupled from the marginal structure and modeled separately. For example, rather than approximating the joint distribution of two risks with a multivariate normal, we can use the copula framework to instill a more precise structure by specifying gamma and lognormal marginals coupled with a Gumbel copula (as shown in Figure 4).



(a) Marginals (b) Gumbel copula (c) Joint distribution

Figure 4. Decomposition of joint distribution into marginal structure and dependence structure.

However, just because the joint distribution can be decomposed into these component parts, does not mean that these component parts are independent of one another. In fact, they are very much linked especially when fitting a copula to data.

There are a variety of ways to fit copulas to data. One of the more popular methods, Inference Functions for Margins (IFM), is a two-step procedure whereby first distributions are fit to the marginals and then maximum likelihood is used to estimate the copula parameters conditional on the marginals fit in the first step. Because this process is order dependent, any misspecification of the marginals in step one will distort the fit of the copula in step two and ultimately the joint distribution. From a risk management context, we should be most wary of marginal distributions

which do not appropriately allow for the possibility of extreme events (i.e., tail risk); from a statistical context, we should be further wary of misspecifying these marginal distributions as the error compounds causing us to *also* often underestimate the likelihood of extreme simultaneous events (i.e., systemic risk).

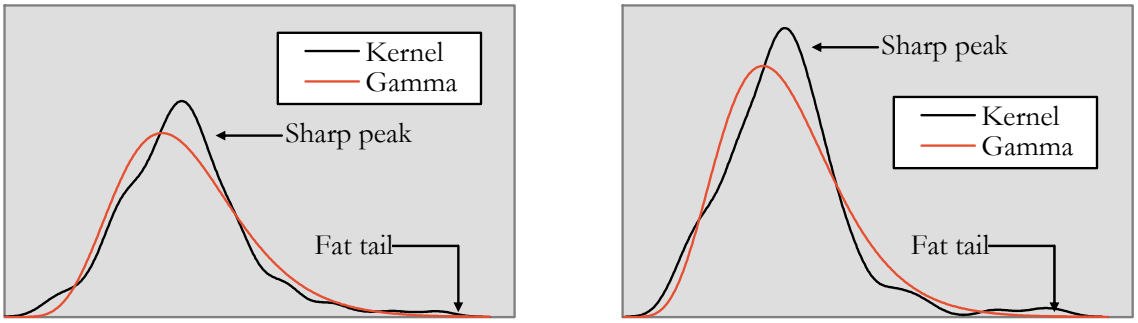
The next section illustrates this "ripple-effect" by comparing both the fit and degree of risk associated with copulas parameterized using various underlying marginal distributions.

3.2 An Illustration

The following example uses data compiled by the Risk Management Agency (RMA) of the United States Department of Agriculture (USDA) for the Federal Crop Insurance Corporation (FCIC). Specifically, we looked at historical corn and soybeans losses (relative to net insured acres) in monthly increments for the period from 1989 through 2008. We show how incorrectly specifying the marginal distribution leads to errors in the calibration of the copula function and ultimately results in CTEs which are understated and an overstated benefit to diversification[5].

This dataset is interesting from a number of perspectives. There is positive dependence between corn and soybean losses (due to common causation by perils such as excess moisture or drought). There is systemic risk (i.e., a peril which completely wipes out a soybean crop in a certain location is also very likely to completely wipe out a corn crop). And there is also evidence of tail risk in the humps, or fat right tails, of the kernel densities fit to historic corn and soybean losses (see Figure 5). It is the fat tails of these marginal distributions which we are most interested in modeling for the time being.

[5] Here, the benefit to diversification is specifically defined as the difference between the sum of the conditional tail expectations and the conditional tail expectation of the sum. This statistic measures the benefit to diversifying with lines of business that are not perfectly correlated. Note that the former statistic does not allow corn (soybean) losses in excess of expectations to cancel with soybean (corn) losses less than expectations. And vice versa. However, the later statistic does and thus the difference provides one measure of diversifying with lines of business that are not perfectly correlated.



(a) Corn (b) Soybeans

Figure 5. Comparison of kernel density with gamma density fit to historical corn and soybean losses.

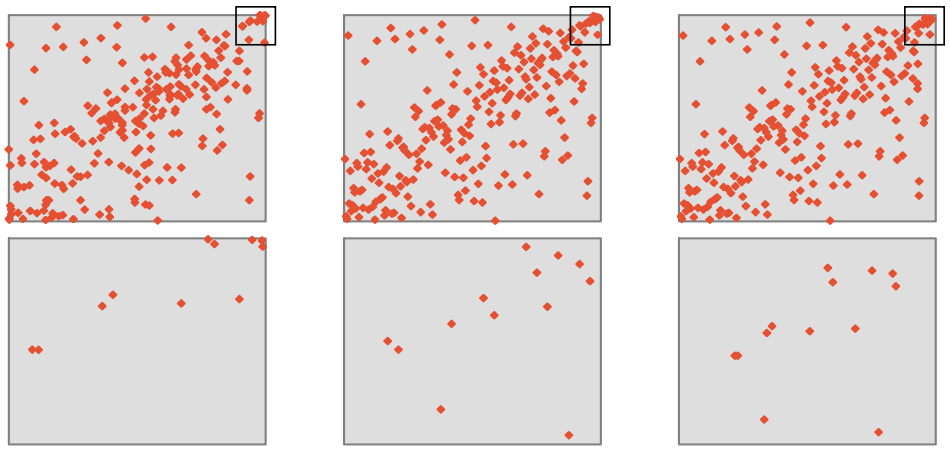
Figure 5 also plots the parametric gamma distribution. Note that this distribution does a poor job mimicking the shape of the data. In order to fit the heavy tail, the two-parameter gamma distribution is forced to contort its shape and in the end equally underfits both the sharp mode and the extreme right tail. Further note that the empirical distribution function may fit the data too closely, degrading its predictive power. However, more importantly, although it is not that evident from these graphs, the empirical distribution function does not adequately assign probabilities to values in excess of the maximum observation in the sample (and kernel density estimates often do a poor job of extrapolation). To this end, the empirical distribution function may not be suitable for modeling tail risk.

To address this later consideration, extreme value distribution, such as the GPD, are often mixed together with another more traditional probability distribution and used to model events in excess of a certain threshold (usually set at a large quantile such as the 90^{th} or 95^{th}). This allows us to account for large losses which may not have been occurred historically but are still expected to be a real possibility in the future.

Figure 6 plots the pseudo-observations of the cumulative probabilities based on either a gamma, empirical, or mixed empirical-GPD fit.[6] The lower panels magnify the area in excess of the 90^{th} percentile (i.e., the observations in the joint right tail). Note that the largest observations in the data, when mapped using the selected gamma distribution, are assigned cumulative probabilities very near to one. For the empirical distribution function, the cumulative probabilities are pushed away from one toward the left corner and for the mixed empirical-GPD these cumulative probabilities are pushed substantially away from one. Essentially, the empirical distribution and the mixed empirical-

[6] Pseudo-observations are the actual observations mapped onto [0,1] using the selected cumulative density function of the marginals.

GPD are assigning greater *survival* probabilities to the observed data in the tail.[7] These larger survival probabilities imply the possibility of observations much larger than that seen in the sample and thus allow for increased tail risk.



(a) Gamma (b) Empirical (c) Empirical + GPD

Figure 6. Top panels show pseudo-observations of corn (x-axis) by soybean (y-axis) losses; bottom panels show magnification of 90th percentile excess.

However, these marginal distributions not only affect our estimates of tail risk, but they also affect the calibration of the copula and ultimately our estimate of systemic risk. Table 3 highlights these results. In this example, the copula parameter is larger for the empirical distribution than the gamma distribution and it is larger for the mixed empirical-GPD than the empirical distribution. This implies increased dependence especially with regard to dependence in the tail of the joint distribution. The CTE is significantly larger for both the empirical distribution and the mixed empirical-GPD distribution as this reflects not only the increased systemic risk, but also the increased tail risk in the marginals. The benefit to diversification is also overstated for the gamma marginals as compared to the mixed empirical-GPD marginal. This is because the possibility of simultaneous tail events greatly reduces the actual benefit from diversifying across these random events.

[7] The survival probability is the probability that a random variate takes a value in excess of a given threshold.

Marginals	Copula	Copula Parameter	CTE(95^{th})	Benefit to Diversification	Cramer-von-Mises Goodness of Fit Statistic*
Gamma	Gumbel	1.88	58.7	5.7%	0.036
Empirical	Gumbel	1.89	82.4	5.6%	0.035
Mixed Empirical-GPD	Gumbel	1.93	106.6	4.8%	0.031

**Smaller values indicate a better fit.*

Table 3. Comparison of copulas fit using the inference functions for marginal approach and various marginal distributions.

Again note that the copula based on more conservative estimates of the underlying marginals (i.e., the mixed empirical-GPD) provides the best fit and thus the more accurate estimates of the actual CTE and benefit to diversification.

3.3 A Good Rule of Thumb

For a variety of reasons, including the rigidity of many parametric distributions as well as the poor job historical data does at capturing the future potential of extreme events, many marginal distributions do not allow for a sufficiently high possibility of large 1-in-*n* year type losses. However, not only do these distributions fail to adequately capture the tail risk, but they also distort the calibration of the copula structure in effect understating the systemic risk. To this end, in order to correctly allow for both tail and systemic risk, it is often advisable to use, or at least consider, an extreme value distribution to model losses above a certain threshold while modeling losses below that threshold with a traditional probability distribution.

4. TAIL DEPENDENCE

This section explores the concept of *tail dependence*. Tail dependence is a specific, asymptotic measure of the dependence between two random variates in the tail of their joint distribution.[8] However, it can be more generally thought of as a good proxy for systemic risk. What is most interesting about the tail dependence statistic is that the normal copula, for all nontrivial

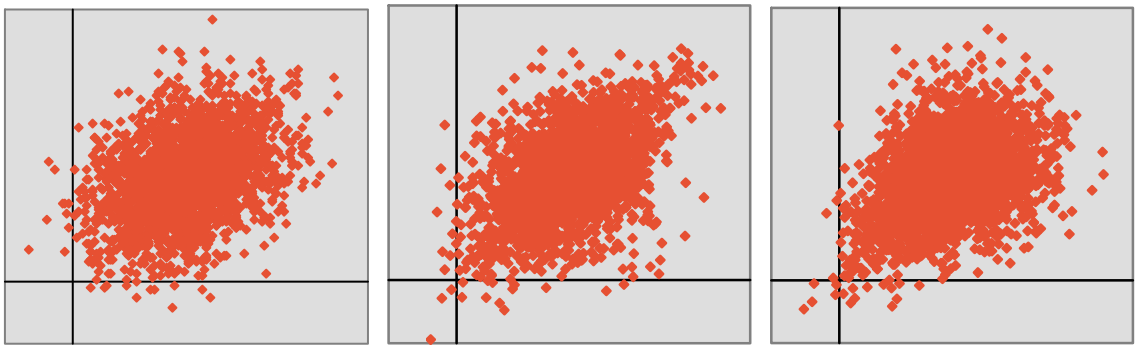
[8] Specifically, tail dependence alludes to the probability that a random variable Y takes a value in the extreme tail of its distribution given that another random variable X has also taken a value in its extreme tail (i.e., consider the scenario where X and Y measure bankruptcy for two companies and both companies simultaneously go bankrupt). Mathematically, the following describes the joint upper tail dependence of random variates X and Y: $\lim_{\alpha \to 1} P(Y > F_Y^{-1}(\alpha) \mid X > F_X^{-1}(\alpha))$.

parameterizations, has no tail dependence. This section explores how systemic risk can be understated when using a normal copula rather than some other copula structure.

4.1 The Relationship between the Assumption and the Risk

Dependence, as discussed in the section 2, is a measure of association between two or more random variables over their entire range. Tail risk, as discussed in section 3, refers to the likelihood and amount of loss in the extreme tails. Tail dependence or systemic risk, however, more pointedly measures the *association* in the *extreme tails* of the *joint* distribution. In this regard, tail dependence is not the same as dependence. It is possible for two random variables to be dependent, but for there to be no dependence in the tail of the distributions. This is exactly the situation described by the normal copula and referenced in Figure 1.

Figure 7 illustrates this concept by plotting bivariate random observations generated from copulas fit to daily stock returns for two large reinsurers over the period 1996 through 2008. The graphs have been divided into quadrants where the lower left quadrant represents simultaneous extreme, downward stock movements (i.e., systemic risk). Even though the copulas were fit to the same data, the normal copula produced no joint extreme events. On the other hand, as can be seen from the graphs below, the *t* copula produced three and the Clayton copula produced about five. Note also that the density of the plotted points for the normal copula, as compared to the *t* or Clayton copulas, thins out considerably and quickly as the simulated observations tend toward the left.



(a) Normal Copula (b) *t* Copula (c) Clayton Copula

Figure 7. Plots of random observations generated from various copulas.

Table 4 shows the upper and lower tail dependence statistics for these copulas. Even though these returns show association as measured by Kendall's *tau*, for the normal copula the tail dependence is zero (whereas it is positive for both the *t* and Clayton copulas). Furthermore, note that the Clayton copula puts the entire tail dependence in the lower left tail whereas tail dependence

is symmetric for the *t* copula.

Copula	Kendall's *tau*	Tail Dependence Lower	Tail Dependence Upper
Normal	0.25	0.00	0.00
t (df=4.45)	0.25	0.17	0.17
Clayton	0.25	0.35	0.00

Table 4. Tail dependence statistics for various copulas.

4.2 An Illustration

Suppose we are interested in estimating the default risk of a portfolio of two, million dollar reinsurance recoverables. Assume there is 100% loss on default (i.e., Bernoulli marginals) and that the probability of default is approximately 3.0%. Also assume that the dependence can be described using a Kendall statistic of 0.25. We fit four different copula structures to this data—the normal copula as well as three members of the extreme value family of copulas which all have strong upper tail dependence (approximately 30% in this situation).

Table 5 compares the probability distribution of defaults across the various copulas. Here, the probability that both reinsurers simultaneously default is about 2.5 times as large with the extreme value copulas than with the normal copula. This is because the extreme value copulas allow for a greater possibility of joint default (i.e., simultaneous extreme events). Further, the probability that neither company defaults is also higher with the extreme value copulas. The immediate implication is that one-parameter copulas, of which all of these are, may not be versatile enough to capture the more complex relationships between jointly distributed random variates. In this specific hypothetical, no copula can be said to be "most correct," instead it is necessary to assess not only the input parameters (i.e., Kendall statistic of 0.25), but the output probabilities (i.e., 94.4/5.2/0.6 vs. 95.0/4.0/1.0) as well for reasonableness.

		Extreme Value Copulas		
Probability of:	Normal Copula	Galambos	Gumbel	Husler Reiss
No Defaults	94.4%	95.0%	95.0%	95.0%
One Default	5.2%	4.0%	4.0%	4.0%
Both Default	0.4%	1.0%	1.0%	1.0%

Table 5. Probability distribution of defaults.

Table 6 compares the CTE at various thresholds. While the CTE is approximately equivalent at the lower thresholds, it grows increasingly fast for the extreme value copulas. This is because the extreme value copulas model a higher percentage of joint defaults than would be the case with the

normal copula. Without commenting on the appropriateness of one copula over another, the extreme value copulas allow us to be more conservative when estimating the possibility of default, which might just be a good thing.

		Extreme Value Copulas		
Threshold	Normal Copula	Galambos	Gumbel	Husler Reiss
50th	120K	120K	120K	120K
75th	240K	240K	240K	240K
90th	600K	600K	600K	600K
95th	1.10M	1.20M	1.20M	1.20M
97.5th	1.16M	1.39M	1.40M	1.40M
99.9th	1.41M	1.97M	1.98M	1.97M

Table 6. CTE at various thresholds.

4.3 A Good Rule of Thumb

There is too often a tendency to focus on the central moments and distribution of data while ignoring behavior in the tails. In a risk management context, this tail behavior is often the most important driver of results and as such should be given a great deal of care. Where it is possible to get good estimates of tail dependence coefficients, these should be included in the selection and calibration of copulas. If this is not possible, due consideration should be given to the nature of the data specifically with regards to expected behavior in the tails of the distribution. This expert opinion should then serve as much of the basis for the final copula structure.

5. (A)SYMMETRY

Copulas are either symmetric or not – this section focuses on the relationship of symmetry with tail risk (associated with univariate asymmetry) and systemic risk (associated with multivariate asymmetry). Two of the most commonly used copulas, the normal and the *t*, are both symmetric and as such behave identically in the left tail as in the right tail. However, in a risk management context, it may not be ideal to model extreme negative outcomes in the same manner as with extreme positive outcomes. More often, positive outcomes may be associated with general run-of-the-mill probabilities whereas negative outcomes are associated with the unlikely 1-in-*n* year events. Modeling these opposite tails in a similar manner will generally lead to undervaluation of the true risk as both the tail risk and systemic risk will generally be understated.

The concept of kurtosis is also discussed within the context that distributions and copulas which

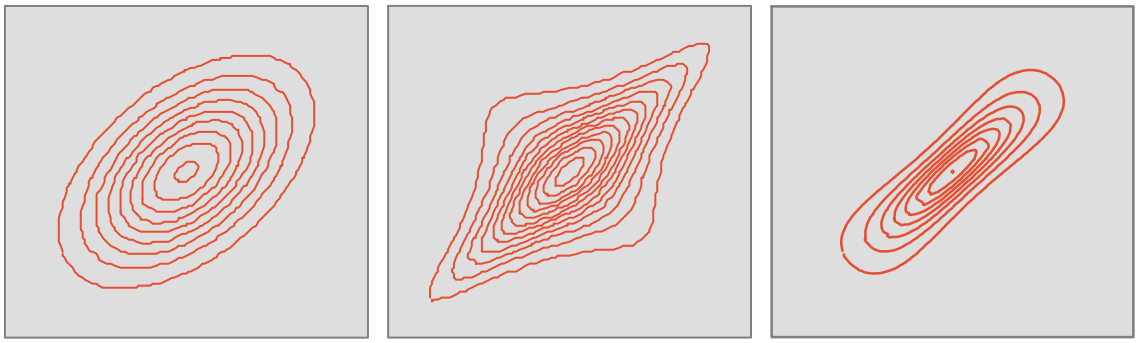
are leptokurtic (i.e., have a higher peak of probability around the mean as well as fatter tails) are more risky.

5.1 The Relationship between the Assumption and the Risk

The normal distribution is an extremely elegant formulation which, because of its mathematical properties, appears again and again in theoretical statistical research. However, it appears less in the real world, as most empirical data just doesn't behave that nicely. Most statistical tests of normality (i.e., does the data follow a normal distribution) are based on the skewness statistic and the kurtosis statistic. Skewness measures symmetry about the mean with the normal distribution being symmetric. Kurtosis, or more specifically excess kurtosis, measures the peakedness of a distribution relative to the normal distribution. Excess kurtosis statistics greater than zero imply a sharper peak in probability around the mean as well as fatter tails than the normal distribution (i.e., increased tail risk).

With that said, two of the most popular copulas are still both symmetric – the normal and the *t*. Perhaps the major criticism of the normal distribution is that there is no tail dependence and thus it is not appropriate for modeling extreme events. However, because it is symmetric it is often not appropriate for modeling most real-world events, many of which tend to have an unlimited downside with only a limited upside. Furthermore, the tails of the normal distribution are considered to be rather thin (i.e., there is a low probability of events at large distances away from the mean). On the other hand, while the *t* copula has both fatter tails than the normal distribution (i.e., positive excess kurtosis) and nonzero tail dependence, it is still symmetric about the mean. In fact, perhaps the major criticism of the *t* copula is that there is only one parameter, specifically the degrees of freedom, which can be used to model the tail dependence.

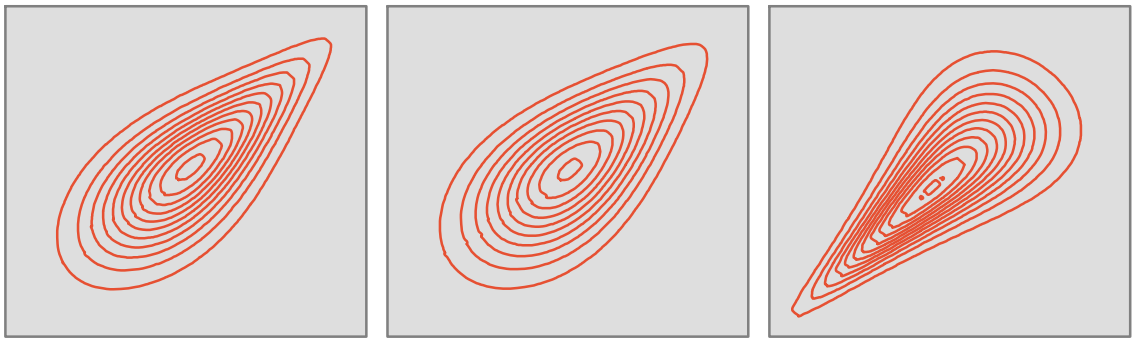
Figure 8 shows the symmetry of the normal and *t* (as well as Frank) copulas by plotting the probability contours (i.e., 2-D representations of the 3-D probability similar to that shown in Figure 4(c)).



(a) Normal copula (b) *t* copula (c) Frank copula

Figure 8. Common symmetric copulas.

Figure 9 shows contour plots of some common asymmetric copulas. The first two, the Galambos and the Husler-Reiss, are both members of the extreme value family of copulas (along with the Gumbel copula referenced elsewhere) which are characterized both by strong upper tail dependence and right skew. Conversely, the Clayton copula, shown in Figure 9(c), is also an asymmetric copula, but it is instead left-skewed with strong lower tail dependence (and zero upper tail dependence).



(a) Galambos copula (b) Husler-Reiss copula (c) Clayton copula

Figure 9. Common asymmetric copulas.

5.2 An Illustration

The following example uses data compiled by the Florida Office of Insurance Regulation (FLOIR) on the loss and allocated loss adjustment expense (ALAE) associated with medical professional liability (MPL) closed claims for the period from 2000 through 2009. We show how symmetric copulas do a poor job of fitting the empirical skewness and kurtosis of the data and thus understate the risk.

Figure 10 plots the log of loss amounts by the log of ALAE amounts. There is a definite positive dependence between loss and ALAE amounts (i.e., as loss amounts increase, so generally do ALAE

amounts), however what is more interesting is the presence of both a strong right skew and upper tail dependence (contrasted with weak lower tail dependence). Although it is not entirely evident from the graph, this data is also extremely peaked, or leptokurtic, meaning that this data has fatter tails than the normal distribution (i.e., increased tail risk).

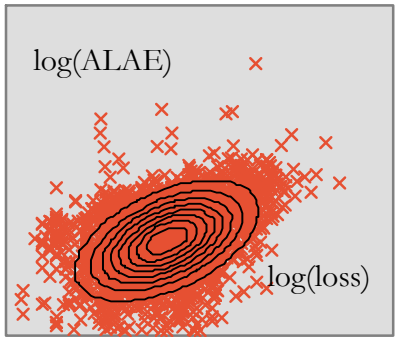


Figure 10. Scatterplot of the natural logarithm of loss and ALAE amounts. A contour plot of the normal copula fit to this data has been overlaid to show how the normal copula fails to adequately capture the shape of the data (i.e., strong right skew and loose left dependence).

Figure 10 makes sense given the possible nature of the data. There is a looser relationship in the lower left corner (i.e., weak lower tail dependence) as small loss payments may be associated with either a constant ALAE per small loss or a large amount of expense perhaps associated with defense which then resulted in a small payment. We would also expect there to be large variations in loss amounts given small ALAE amounts as many claims settle relatively painlessly regardless of the size of loss. There is a tighter relationship in the upper left corner (i.e., strong upper tail dependence) as very large loss amounts are generally associated with very large ALAE payments. Further, note the increased density of points around the median loss and ALAE amounts which gradually taper off in the direction of the upper right corner. This is consistent with a positive excess kurtosis and right skew, respectively, both of which imply increased systemic risk.

To measure the skewness and excess kurtosis, we use Mardia's multivariate extensions of the common skewness and kurtosis statistics. The normal copula will generate values of zero and zero. Table 7 compares the actual skewness and kurtosis of the data against various copulas fit to the data. Note that the skewness statistics for the symmetric copulas are zero and for the asymmetric copulas are greater than zero indicating a right skew. None of the traditional copulas provide a particularly good fit to the data with respect to capturing the risk in the right tail. In all of these examples, the copulas are unable to fully capture the extreme multivariate behavior of the underlying data and as such will understate the ultimate risk. The skew *t* copula does slightly better but still understates the

skewness while overstating the kurtosis.

Copula	Symmetry	Skewness	Excess Kurtosis
Actual	**Asymmetric**	**0.50**	**1.50**
Normal	Symmetric	0.00	0.00
Frank	Symmetric	0.00	0.10
t	Symmetric	0.00	0.25
Galambos	Asymmetric	0.10	0.15
Gumbel	Asymmetric	0.10	0.25
Skew *t*	Asymmetric	0.40	1.80

Table 7. Multivariate skewness and excess kurtosis statistics of copulas fit to the log of loss and ALAE amounts. The actual skewness and kurtosis are included as reference.

5.3 A Good Rule of Thumb

To some extent, many of the concepts we rely upon when modeling univariate distributions apply just as well when modeling multivariate distributions. Specifically, if we do not use the normal distribution to model loss severities because the normal distribution is not skewed, why should we use it to model multivariate loss severities. Put another way, because multivariate structures are more difficult to conceptualize than univariate structures, it may often be easiest to think about multivariate modeling in terms of univariate best practices.

Further, it is important to note that although we may often rely on data to determine the ultimate shape of our curves, with copulas the ultimate shape is perhaps more a product of theoretical considerations than it is of data parameterization. As such, prior to fitting copulas to data, it is necessary to take a step back and decide on which copula(s) – symmetric or not, kurtic or not – have a natural interpretation and make sense given any prior knowledge of the risks.

6. CONCLUSION

Perhaps even more so than other statistical techniques, the application of copulas is often more art than science. There will generally never be that one obviously correct answer; however, there are often many wrong answers. More specifically, there are many copula structures which fail to adequately account for the behavior in the extreme tails of univariate and multivariate loss distributions and as such greatly understate the tail and systemic risk. This paper has highlighted several considerations with regard to more appropriately capturing both the tail and systemic risk, including using measures of association more robust than linear correlation, using extreme value

theory to model the marginals, selecting a copula which appropriately captures the tail dependence and accounting for the skewness and kurtosis of the underlying data.

However, perhaps most important in the selection of the copula, and the best rule of thumb, is to select a copula which has a natural interpretation (i.e., it makes sense and can be explained) and is consistent with expectations of risk remembering always that the future will never be quite as simple as the past.

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[22] K. Mardia, "Measure of Multivariate Skewness and Kurtosis with Applications," *Biometrika*, **1970**, Vol. 57, No. 3, 519-530.

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Abbreviations and notations

ALAE, allocated loss adjustment expense
CAL, commercial automobile liability
CMP-Property, commercial multiple peril (property portion)
CMP-Liability, commercial multiple peril (liability portion)
CTE, conditional tail expectation
df, degrees of freedom
FCIC, Federal Crop Insurance Corporation
FLOIR, Florida Office of Insurance Regulation
GL, General Liability
GPD, generalized Pareto distribution
IFM, inference functions for margins
MPL, medical professional liability
RMA, Risk Management Agency
TXDOI, Texas Department of Insurance
USDA, United States Department of Agriculture

Biography of the Author

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Note from the Editor on Gail E. Tverberg's "The Expected Impact of Oil Limitations on the Property-Casualty Insurance Industry"

By Glenn M. Walker, FCAS, MAAA, *E-Forum* Committee Chairman

The paper that follows, "The Expected Impact of Oil Limitations on the Property-Casualty Insurance Industry," traces the consequences of a worldwide (or even simply a local) oil shortage on the economy as a whole. The primary thesis is that no single segment of an economy rises and falls without consequence to several, if not all other segments. The property-casualty insurance industry is one such affected segment.

Author Gail E. Tverberg, though not offering advice on how casualty actuaries should prepare for or respond to these consequences, provides a very thorough description of the challenges that the members of the Casualty Actuarial Society might be called on to overcome. The more obvious consequences include a reduction in investment income as the economy at large suffers shrinkage. More subtle consequences include the deterioration of homeowners experience as the gap between replacement cost and market value expands.

Indeed it would be overwhelmingly difficult for Ms. Tverberg to offer a roadmap for us actuaries to follow. While it should be stressed that the opinions expressed are not necessarily shared by the CAS, the *E-Forum*, or its editor, should the anticipated oil shortage be sufficiently severe, only a fraction of the actual consequences can be foreseen, even by the most prophetic among us. Yet we should not too casually accept the vacuums of consequence whereby we respond, "I didn't even think of that one."

Though the focus is on the overall economy first, and the property-casualty insurance industry second, the Editor welcomes this paper's contribution to the *E-Forum*.

The Expected Impact of Oil Limitations on the Property-Casualty Insurance Industry

By Gail E. Tverberg, FCAS, MAAA

Abstract

Using the principles of Biophysical Economics, together with the issue of resource constraints that the world is already facing (particularly with respect to oil), we show that the financial crisis that affected many industries in the 2008 -2009 period, including the property-casualty insurance industry, was not a one-off event. Instead, the financial crisis was closely tied to inadequate growth in world oil supplies, leading to higher prices of crude oil, which in turn affected credit markets, creating recessionary impacts.

If the growth in world oil supplies continues to be constrained, this analysis indicates that the recently-experienced financial crisis can be expected to be repeated, and get worse, resulting in impacts affecting many of the same lines of insurance as those affected during the 2008-2009 crisis.

As the restriction in oil supply becomes greater, we show bond default rates can be expected to increase greatly. These high default rates can be expected to lead to the eventual bankruptcy of companies writing financial guarantee insurance and result in erosion of capital of property-casualty insurers. An increase in bankruptcies of property-casualty insurance companies is indicated, quite possibly exceeding the capacity of guarantee funds.

Keywords: Biophysical Economics; bond default rates; financial crisis; oil; peak oil; recession; resource constraints; world oil supply

1. INTRODUCTION

There is a popular view of the recent financial crisis based on one set of economic theories ("classical" or "orthodox" economic theory) and one view of the importance of energy for future GDP (not very important, based on classical economic theory). Holders of these views tie the financial crisis to the subprime mortgage crisis which in turn was related to too loose credit policies in the 2002-2005 period, combined with the fall in housing prices, starting in late 2005 or early 2006.[1] Securitization of loans was also a factor, because banks could easily make more loans than were prudent, package them and resell them to unwise investors, and make a profit on the fees they received.[2] When all of the problems with these loans surfaced, banks required major bailouts, and a major financial crisis ensued. We are now working through the aftermath. With better financial regulation, the crisis should not happen again—or so the story goes.

[1] "Subprime Crisis Impact Timeline," *Wikipedia,* http://en.wikipedia.org/wiki/Subprime_crisis_impact_timeline.

[2] Shah, Anup, "Global Financial Crisis." *Global Issues,* 22 Aug. 2010, http://www.globalissues.org/article/768/global-financial-crisis#Securitizationandthesubprimecrisis.

There is another version of the story as well—one based on a different view of the economics ("biophysical" or "ecological" economics) and a different view of the importance of energy supplies to the economy (very important – a decline, even if only in oil production, is likely to have serious economic consequences—and even level oil production is a serious problem).

With the biophysical economic view of the story, while there may have been contributions to our problems caused by the subprime crisis, securitization of loans, and lax regulation, the real underlying issue was increasingly tight oil supplies—a problem that started about late 2004, when oil prices began to rise, and oil production started entering into a production plateau lasting from 2005 to 2010.

The problem can be viewed as one of peak oil supply or peak oil demand—it really doesn't matter which one chooses. Above a certain price, higher oil prices have a crushing effect on the economy, as illustrated by exhibits from Energy Secretary Steven Chu's presentation at the US Energy Information Administration's 2009 Energy Conference:

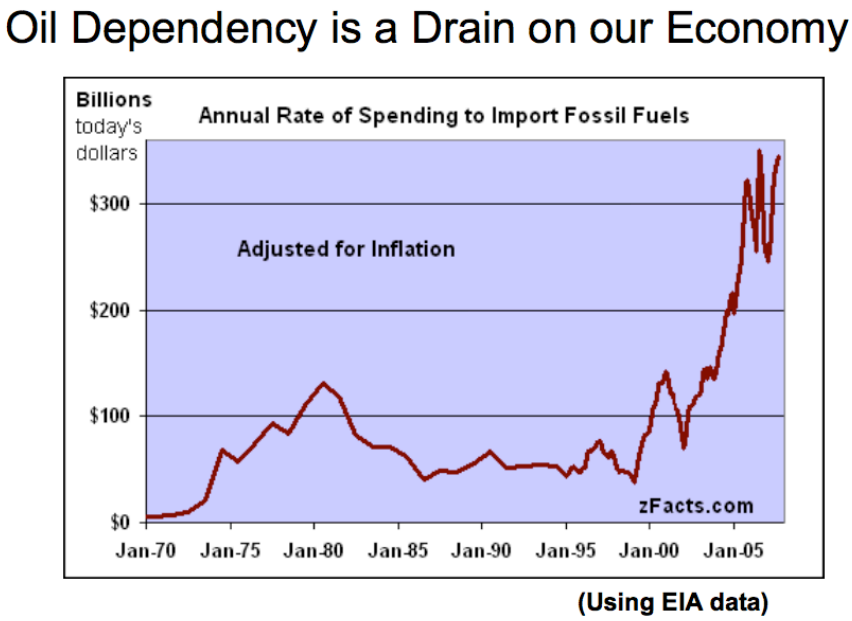


Figure 1 – Graph from Steven Chu presentation showing that high oil prices are a drain on the economy.[3]

[3] Chu, Steven, Presentation from 2009 Energy Conference, 7 Apr. 2009, http://www.eia.doe.gov/conference/2009/plenary/Chu.pdf.

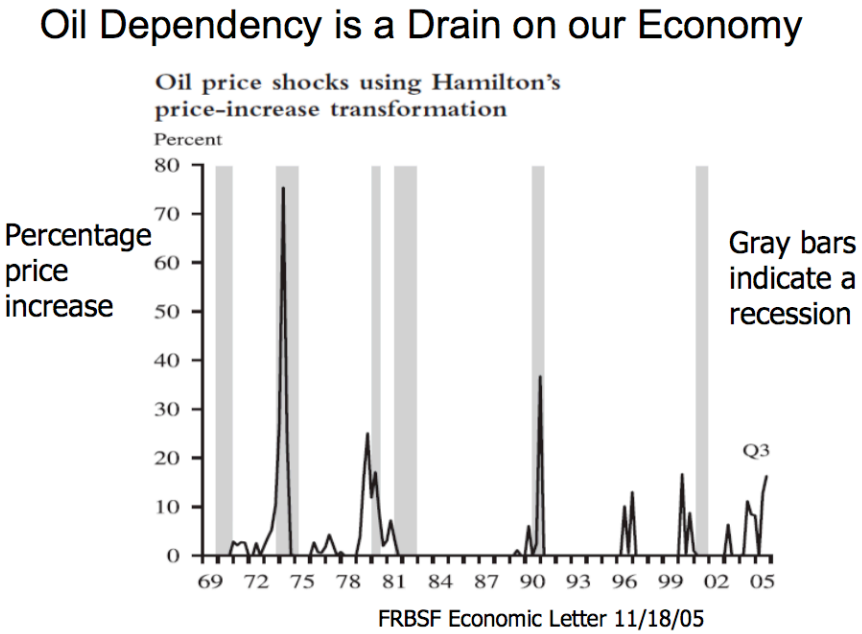


Figure 2 – From Steven Chu Presentation, showing that recessions generally follow oil price shocks.[4]

James Hamilton, referenced in the slide, is an Economist at the University of California, San Diego, known for his work tying oil prices to recessionary impacts. Prior to the latest recession, he developed a model of economic activity, with and without oil price shocks. He found in his model that oil prices seemed to explain the latest downturn, as shown in Figure 3. [5]

[4] Chu, Steven, Presentation from 2009 Energy Conference, 7 Apr. 2009, http://www.eia.doe.gov/conference/2009/plenary/Chu.pdf.

[5] Hamilton, James D., "Causes and Consequences of the Oil Shock of 2007-08," 27 Apr. 2009, http://dss.ucsd.edu/~jhamilto/Hamilton_oil_shock_08.pdf

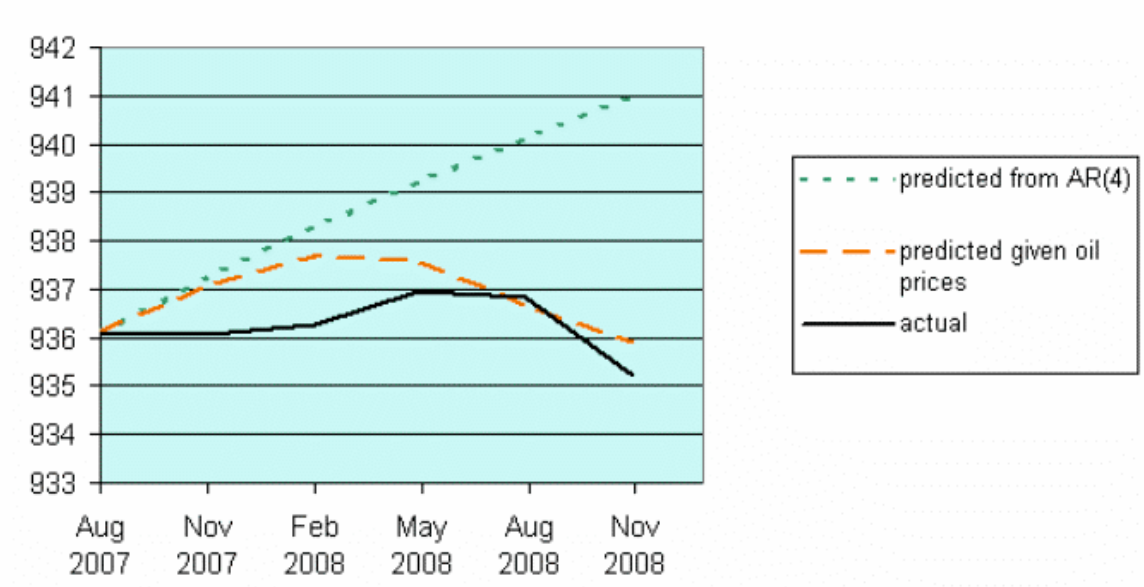


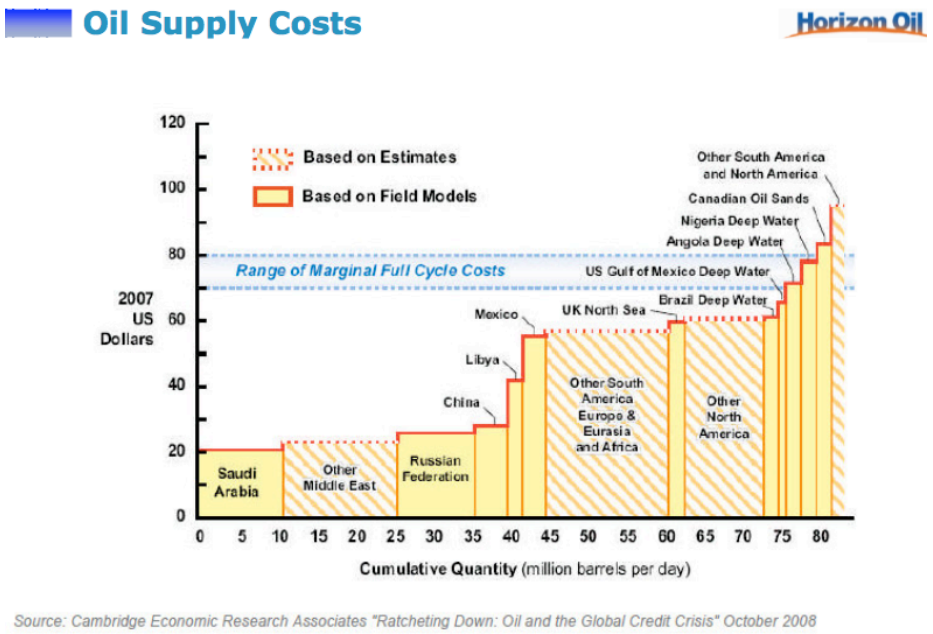
Figure 3. Conditional forecasting of GDP, by James Hamilton.

Note by J. Hamilton: Solid line: 100 times the natural log of real GDP. Dotted line: dynamic forecast (1- to 5-quarters ahead) based on coefficients of univariate AR(4) estimated 1949:Q2 to 2001:Q3 and applied to GDP data through 2007:Q3. Dashed line: dynamic conditional forecast (1- to 5-quarters ahead) based on coefficients reported in equation (3.8) in Hamilton (2003) (which was estimated over 1949:Q2 to 2001:Q3) applied to GDP data through 2007:Q3 and conditioning on the ex-post realisations of the net oil price increase measure.[6]

Without the oil price rise in 2007-2008, GDP would have been predicted to rise as shown with the dotted green line. The actual behavior of the economy fairly closely matched what was expected based on the rise in oil prices. While this was a surprising conclusion, there were a lot of reasons why there might have been a connection. Higher oil prices caused a run-up in both food and energy prices. These had the biggest impact on the part of the population who were most vulnerable—subprime borrowers, living in distant suburbs, and this is precisely where there were the biggest loan problems, early on.

[6]Hamilton, James D., "Oil Prices and the Economic Recession of 2007-2008," *Vox* 16 June 2009, http://www.voxeu.org/index.php?q=node/3664.

Going forward, there is fairly good consensus that the oil prices can be expected to continue to rise, if oil production is to increase, because much of the cheap oil has already been extracted. Figure 4 shows a graph published by Cambridge Energy Research Associates (the largest consulting firm doing work for the oil and gas industry), showing oil prices needed to justify extraction of oil from various locations.



Source: Cambridge Economic Research Associates "Ratcheting Down: Oil and the Global Credit Crisis" October 2008

Figure 4 - CERA estimates of full costs of oil production, from a Horizon oil presentation. The CERA graph was put together when oil was about $90 barrel. The dotted line indicates the highest cost types of production that would be profitable at that price.

Figure 4 indicates that part of the capacity of oil that we are accustomed to using is high priced oil—oil that it does not even make sense to pump when oil is $90 barrel. There is other oil that may be available—oil in ultra-deep water; oil near the North Pole; more oil from the Canadian oil sands, and perhaps oil from oil shale, but all of these are high cost resources. If they had been cheap resources, we would have extracted them earlier, when prices were lower.

As recently as 2002, oil was sold for under $20 a barrel. [7] Now much of the inexpensive-to-extract oil is gone, and we need to keep moving toward more and more expensive oil, meaning that as we demand more oil, it becomes more expensive.

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[7] "Cushing, OK WTI Spot Price FOB (Dollars per Barrel)," *U.S. Energy Information Administration* 22 Sept. 2010, http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M.

Higher oil prices seem to affect the economy in two ways. First, since higher oil prices tend to affect expenditures that we think of as necessities (food and gasoline prices especially), buyers tend to cut back on discretionary spending—an action that tends to lead to recession. Second, some buyers find themselves with inadequate funds to make debt repayments. This leads to higher default rates. I have illustrated this in Figure 5.

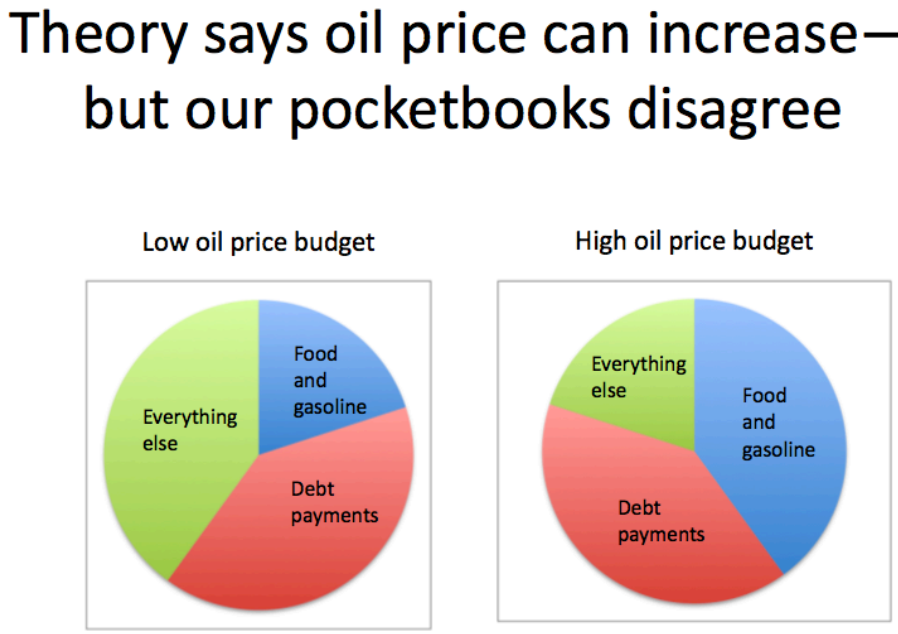

Figure 5 – Graphic by author illustrating that if the price food and gasoline increase, either debt repayment must suffer, or there must be a cut back in discretionary spending. Not to scale. If consumer actually had savings, this might also be affected.

While classical economic thinking says that economic growth is largely dependent on labor and capital as input, biophysical economics says that resource inputs, and in particular oil inputs, are very important to economic growth. A strong relationship between economic growth and real work provided by energy was shown by Robert U. Ayres and Benjamin Warr in "Accounting for Growth: The Role of Physical Work" in 2004.[8]

[8] Ayres, Robert A. and Benjamin Warr, "Accounting for Growth: The Role of Physical Work," *International Energy Agency,* http://www.iea.org/work/2004/eewp/Ayres-paper1.pdf.

This model looks at the amount of work (in a physics sense) that is done by energy. Thus, it considers both the amount of energy used and how productive that energy is. For example, power stations in 1900 converted only 4% of the potential energy in coal to electricity, but by 2000, the conversion efficiency was raised to 35%. This model explains the vast majority of US real economic growth between 1900 and 2000, except for a residual of about 12% after 1975.

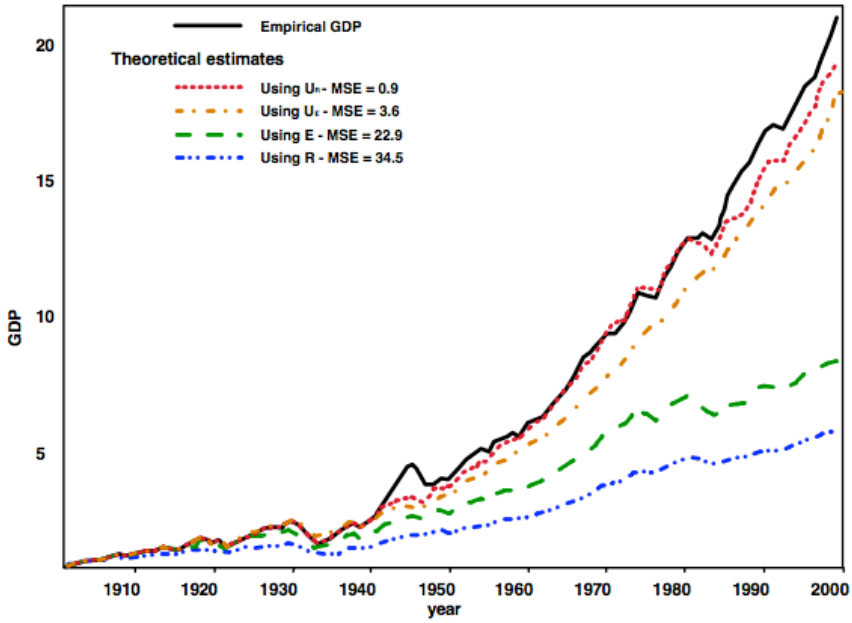

Figure 6 - Results of model by Ayres and Warr. The selected model is the dotted red line, which includes biomass and animal labor, as well as other types of fuels (fossil and nuclear) – From link above.

Oil is the single largest source of energy today, and type of energy source upon which 98% of the world's transportation system depends. Oil is also very critical for food production, since farm equipment uses diesel to operate, transportation of food (and refrigeration during transport) requires oil products, and oil is used in irrigation, fertilizer production and transport, and in the manufacture of insecticides and herbicides.

Recent analyses show a high correlation between world GDP growth and increases in world oil usage.

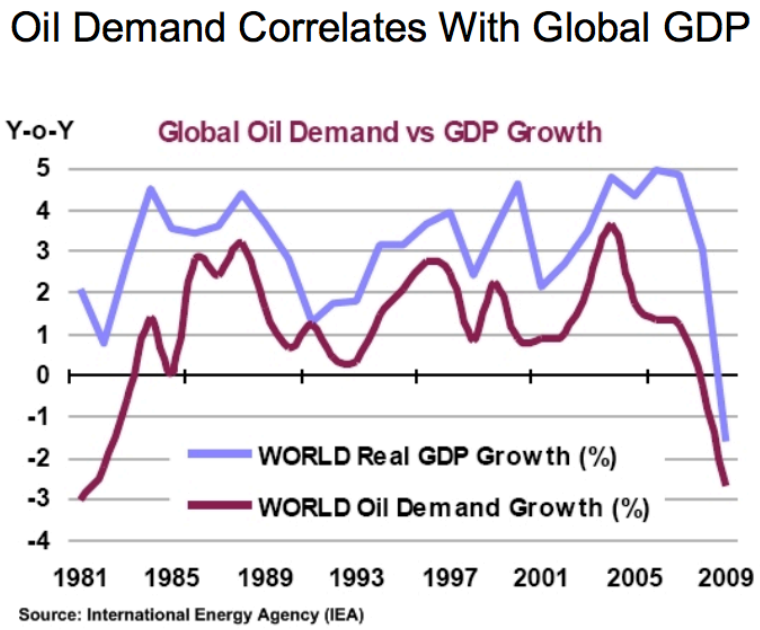

Figure 7 – Graphical relationship of world real GDP growth and world oil demand (usage) growth) by David Cohen, Association for the Study of Peak Oil Conference October 2009, Denver, Colorado [9]

World oil production has been on a plateau since 2005. The real issue is the oil supply really needs to grow, in order to support a growing world economy, and this is no longer happening.

There are different views regarding future oil supply. Figure 8 illustrates one of them, and the huge mismatch that results between the amount of oil that is needed to sustain growth, and the amount that may be available.

[9] Cohen, Dave, "The Aftermath of the Great Recession," Association for the Study of Peak Oil and Gas 5th Annual Conference, 12 0ct. 2009, http://www.aspousa.org/2009proceedings/Dave_Cohen_Oct_12_2009.pdf

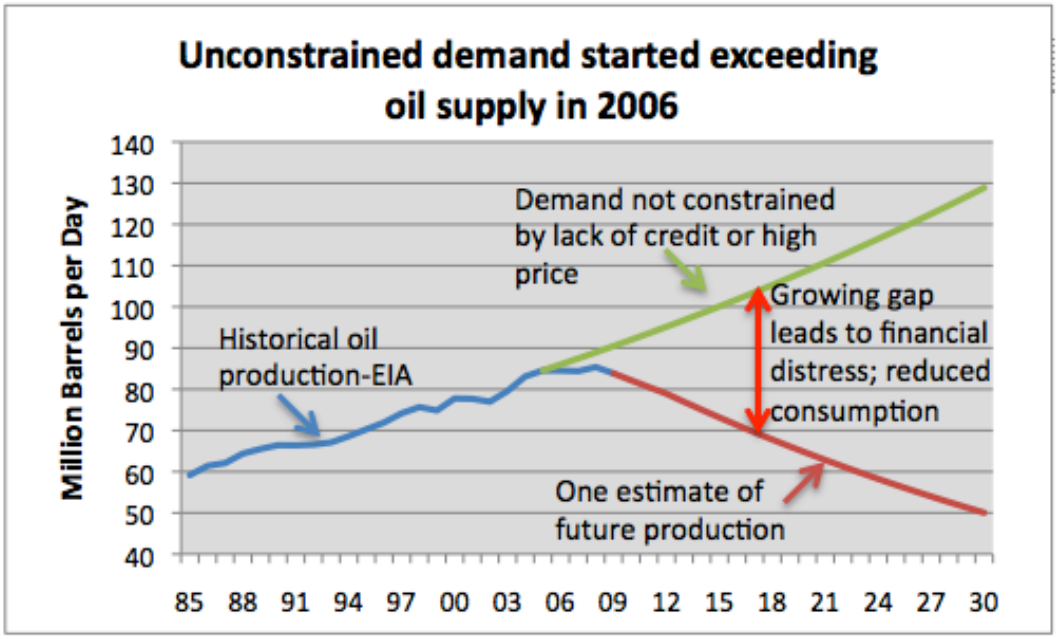

Figure 8 – Illustration that may be ahead, by the author. Historical oil production is "all liquids" (including substitutes, such as ethanol), based on data by the US Energy Information Administration (Table 4.4, International Petroleum Monthly)[10] *Green line represents what supply would need to be, to match historical growth of 1.8% per year.*

Note that oil production does not actually need to drop for economic distress to occur—lack of growth in oil supplies can be expected to have an adverse impact of world real GDP, as illustrated in Figure 7.

Estimates of future oil production vary, but none of them are terribly optimistic. The US Energy Information Agency forecasts oil production below the green line shown (reaching 106 in 2030), but at higher prices. [11]

The Natural Petroleum Council put together for a report for then-Energy Secretary on the issue of future supplies, which they called "Facing Hard Truths about Energy".[12]

The United States Joint Forces Command (which provides planning advice for all areas of the US Military) put out a report earlier this year that says, on page 29, "By 2012, surplus

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[10] "International Petroleum Monthly," *U.S. Energy Information Administration* 10 Sept. 2010, http://www.eia.doe.gov/ipm/supply.html.

[11] "International Energy Outlook 2010," *U.S. Energy Information Administration* 27 July 2010, http://www.eia.doe.gov/oiaf/ieo/graphic_data_liquidfuels.html.

[12] "Facing the Hard Truths about Energy," *National Petroleum Council,* http://www.npchardtruthsreport.org/.

oil production capacity could entirely disappear, and as early as 2015, the shortfall in output could reach nearly 10 million barrels a day."[13]

All of this is not an issue if one believes classical economics, and its view that only labor and capital (and innovation) are important. If one believes the tenets of Biophysical Economics, the likely inadequate growth in oil production in the next few years (which may in fact be a decline in oil production) is likely to cause serious financial disruption.

2. WHAT DOES THIS HAVE TO DO WITH THE PROPERTY CASUALTY INSURANCE INDUSTRY?

Most readers have already been through one financial crisis, and have a good idea what a similar one would look like for their company. Some of the impacts experienced in the last run-through would include:

1. Decline in exposures. If this occurs over the long term, it can be expected to put upward pressure on expense ratios.
2. Better auto insurance experience. If oil prices are higher, there is less discretionary driving, and claim experience improves.
3. Poor homeowners experience. More vacant homes, more homes that homeowners plan to give back to the bank shortly, declining property values.
4. Terrible loss experience on financial guarantee insurance, and very poor loss experience for mortgage guarantee insurance.
5. Very poor investment income.
6. Declining valuations of some investments, such as CDOs, and more bond defaults.
7. Poor workers compensation experience, through the period of layoffs and lower payrolls.

Pretty much all of the foregoing list can be tied to higher oil prices, higher debt defaults, the resulting credit contraction, and the ensuing recession. As debt defaults rose, credit availability was cut back, leading to a further reduction in spending, and more layoffs. With layoffs, more people defaulted on their mortgages, and prices on homes tended to drop. There was a flight to safety on investments, and government interest rates especially tended

[13] "Joint Operating Environment," *United States Joint Forces Command* 2010, http://www.jfcom.mil/newslink/storyarchive/2010/JOE_2010_o.pdf

to drop. Low interest rates were also encouraged by Federal Reserve policy, in an attempt to get the economy out of its slump.

We have recently had somewhat of a bounce back from the financial crisis, partly as a result of lower oil prices (resulting from lower demand caused by credit cutbacks and recession), stimulus spending, bailouts for banks, and the greater discretion that banks now have in valuing their difficult-to-value investments.

Going forward, this analysis indicates that there is a high probability of something very similar happening again, only this time getting significantly worse. It is possible that there will be a bounce back from the next recessionary drop, but if this happens, another further drop will happen within two or three years. Eventually, bond defaults and debt defaults of all kinds will get to be such a problem that many insurance companies will fail, at rates far above the level that guarantee funds are set up to handle. To explain a little why this is expected, I offer some information about a forecast I made that led to an invitation to give a presentation at 2009 Biophysical Economics Conference at SUNY-ESF, Syracuse, New York.

3. FORECASTS FROM EARLY 2008

Back in 2007 and early 2008, I was one of the people looking at oil shortages, and the likely impact of these shortages on the financial system. At the beginning of 2008, I published an article, which foretold many of the happenings of the 2008 financial crisis, and explained some of the reasons why. To quote from that article[14]:

> At this time of year, we read many financial forecasts for the year ahead. Nearly all of these are written with the "filter" assumption of infinite growth. "Oil production problems are a temporary issue; after a short dip, the economy is likely to continue growing rapidly again. We may have a short recession, but we will soon be back to business as usual." Etc.
>
> I think this filter is fundamentally in error, and leads to a mistaken impression with respect to where the world is headed. The world is changing in a very major way. Oil is in short supply, and this shortage is likely to get larger in the future. The pressure of short supply and rising prices adds a systematic bias that the financial community is not recognizing. This bias has as its basis the fact that it is becoming

[14] Tverberg, Gail, "Peak Oil and the Financial Markets: A Forecast for 2008," *The Oil Drum* 9 Jan. 2008, http://www.theoildrum.com/node/3382.

more and more difficult for both people and businesses to pay back loans, because of the rising costs of oil and food. This situation cannot be expected to go away. In fact, it is certain to get worse in years ahead, as oil supplies become tighter.

Besides the systematic bias, there is also a systemic risk, arising from the interconnectedness of all of the parts of the economy. This was well described in a post a few days ago called "The Failure of Networked Systems."[15] One of the issues in systemic risk relates to the financial system itself. If one party in the financial system fails, it increases the likelihood that other parties in the economic system will fail as well.

Another aspect of systemic risk is the close ties of the financial system to the rest of the economy. One example is the higher oil and food prices mentioned above that lead to a systematic bias toward higher defaults. Another is the fact that the lack of oil can be expected to impede economic growth, making the infinite growth model underlying the current economic system less sustainable, based on the economic model of Robert Ayres and Benjamin Warr[16]. Another linkage is that of oil with ethanol. Higher oil prices leads to increased pressure to produce more ethanol, which further raises food prices, as demonstrated by Stuart Staniford in "Fermenting the Food Supply."[17]

Later in the article, I explain further about the issue:

First, some definitions to go with the introduction.

Systematic bias occurs in a system when a process favors a particular outcome. Instead of errors being random, they are consistent and repeatable. One example might be a thermometer that consistently reads high. In the economy, systematic bias occurs when loans experience a greater and greater tendency toward defaults, because of changes in the system (rising oil prices) since the time when the probability of default was originally estimated. As another example, rising oil prices can also cause profits of individual companies to grow more slowly than expected (relative to base period experience) because of a contraction in general economic growth.

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15 Aeldric, "The Failure of Networked Systems," *The Oil Drum* 6 Jan. 2008, http://anz.theoildrum.com/node/3377#more.

16 Ayres, Robert A. and Benjamin Warr, "Accounting for Growth: The Role of Physical Work," *International Energy Agency,* http://www.iea.org/work/2004/eewp/Ayres-paper1.pdf.

17 Staniford, Stuart, "Fermenting the Food Supply," *The Oil Drum* 7 Jan. 2008, http://www.theoildrum.com/node/2431#more.

Systemic risk is risk relating to the interconnectedness of the system. A push on one part of the system will lead to a pull on another part of the system, leading to unanticipated failures. As an example, the failure of one bank may lead to other banks failing, because of counter party risk. There is significant reason to believe that the interconnectedness of the system is increasing over time, as food becomes used as a fuel, and as financial products become more complex. See "The Failure of Networked Systems."[18]

The financial community has designed many models. Some of these are used by "quants" in pricing the newer sliced and diced financial products. Others are used by insurance companies in pricing the risk of defaults on bonds and on mortgages.

The assumption that is made in these models is that historic experience can be used, with only minor adjustments, as a guide for pricing current products. This approach fails to recognize the greater risk now entering the system, due to systematic bias because of rising oil prices, and due to greater systemic risk, because of greater interconnectedness.

One way of describing these models is to say that they assume that defaults are "independent events"—that is, there is no systemwide bias that would cause more and more defaults. This assumption of independence keeps insurance prices low, and makes the slicing and dicing of packaged securities work. Clearly, with the systematic bias and systemic risk that is now infecting the financial system, these assumptions are no longer valid.

Closely related to the assumption that events are independent is the assumption that distributions are "normal"—that is that they follow the Gaussian distribution. Benoit Mandelbrot has shown in *The (Mis)Behavior of Markets* that the actual tails of distributions are much "fatter" than implied by the Gaussian distribution. The bias introduced by the oil situation makes the normal distribution even less appropriate. For example, with higher oil prices, the number of defaults on bonds will be much greater than would be predicted, if one simply assumes that a normal distribution applied to past experience will be predictive of future experience.

If one looks at financial theories like the "Capital Asset Pricing Model"[19] and the

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[18] Aeldric, "The Failure of Networked Systems," *The Oil Drum* 6 Jan. 2008, http://anz.theoildrum.com/node/3377#more.

[19] "Capital Asset Pricing Model," *RiskGlossary.com,* http://www.riskglossary.com/link/capital_asset_pricing_model.htm

"Black and Scholes Option Pricing Model,"[20] one discovers that they assume normal distributions and statistical independence. These models were not quite right before, because the underlying distributions are not really normal, as shown by Mandelbrot. Now that systematic bias and systemic risk are playing greater roles, the predictive value they had previously can be expected to further decline.

My predictions for the economy, and the effect on the insurance and banking industries turned out to be quite accurate—certainly more than those of most other financial analysts.

4. *DELUSIONS OF FINANCE* PRESENTATION AT 2009 BIOPHYSICAL ECONOMICS CONFERENCE[21]

Professor Charles A. Hall of SUNY-ESF, Syracuse, New York was in charge of the program for the 2009 Biophysical Economics Conference in New York. He had heard of my work, and had seen how accurate my forecasts had proven to be. Even though I am not trained as a biophysical economist (although I am doing very similar work), he asked me to give a presentation at the 2009 Biophysical Economics Conference, explaining what mainstream economists had gotten wrong, and what this implies for the path ahead. He suggested a title of "Delusions of Finance." [22]

Let me quote a little some from this presentation:

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[20] Rubash, Kevin, "The Black and Scholes Model," *A Study of Option Pricing Models,* http://bradley.bradley.edu/~arr/bsm/pg04.html

[21] *Biophysical Economics Conference,* http://web.mac.com/biophysicalecon/iWeb/Site/BPE%20Conference.html.

[22] Tverberg, Gail E., "Delusions of Finance: Implications for Where We are Headed," 2nd Biophysical Economics Conference 16 Oct. 2009, http://web.mac.com/biophysicalecon/iWeb/Site/BPE%20Conference_files/Download%20Tverberg.pdf

Slide 3:

Forecast in January 2008

- Higher loan defaults
- Bond insurer downgrades; insolvencies
- Loans will become less available
- Large bank failures
- Fannie Mae, Freddie Mac need assistance
- Recession in 2008, getting worse during year
- Sudden discontinuity may make thing worse

Slide 4:

What did others miss?

- Oil shortages -> economic decline
- Economic decline -> ***lots*** of debt defaults
- ***Lots*** of debt defaults -> troubled financial system
- Insurance programs set up protect financial system missed ***systemic risk***
- Major debt unwind is still ahead

Slide 5:

Oil Shortages -> Economic Decline

- Oil price rose, so food, gasoline prices rose
- Less money left for
  - Discretionary purchases; contributions
  - New house purchases
  - New car purchases
- Led to reduced sales; layoffs
- Dave Murphy: $80 oil (retail 5.5% of GDP; wholesale 4.0% of GDP) leads to recession

Slide 6:

Economic decline -> *Lots* of Debt Defaults

Repaying loans is easy in a growing economy

Repaying loans is much more difficult in a shrinking – or flat - economy

Slide 7:

Economic Decline -> *Lots* of Defaults

Growth	Decline

• Rising property values
  • Pull equity out, use it too!
	• Declining property values
	  • Why not walk away?

• Layoffs rare	• Layoffs common

• Business margins better
  • Easy to pay off debt
	• Business margins down
	  • Debt hard to pay back

• Government revenue up
  • Easy to pay off debt
	• Government revenue down
	  • Hard to pay back debt

If a person stops think about the situation, there a quite a few differences in the way the economy functions in a period of economic growth and in a period of economic decline. The assumption of continued economic growth by traditional economists (who don't consider resources and their limits) has been so strong that most have not even considered what the economy would look like in a period of long-term decline.

Slide 8:

Lots of Defaults -> *All* Financial Institutions in Trouble

- Financial system was not set up for lots of defaults
- Defaults erode the equity of banks, insurance companies, pension plans, etc.
- Government can "paper over" this problem, but it will keep coming back
  - Many more defaults ahead
  - Eventually governments likely to have troubles, too

Many have observed that there would have been defaults, even without peak oil, because of the reckless lending that had been done. I would contend that at least part of the reason the lending had been done was to give the illusion of growth, when there really wasn't much apart from that generated from very loose lending standards. Furthermore, even if loose lending standards were part of the problem, the problems related to peak oil made it worse (and can be expected to cause more problems in the future).

Slide 9:

Financial system insurance programs missed *systemic risk*

- Insurance programs for banks, pension plans, insurance companies all assume debt defaults are "***independent***"
  - Defaults unlikely to be a problem for several institutions as once
- Funding way too low to handle systemic risk
  - Problem for FDIC, Pension Benefit Guarantee Corp, insurance company guarantee plans, Fannie Mae and Freddie Mac equity requirements

When there isn't a problem like a limitation on the amount of oil available (or limits to growth in general), debt defaults are, in fact, pretty much independent. That is why the system for determining insurance charges to be included in the interest rates charged for loans worked pretty well until peak oil came along. In the absence of peak oil, a homeowner or businessman defaults because of some particular problems he or she has. Past history is likely to be predictive of the future, because while there are different individuals defaulting, the average number of defaults will tend to be pretty stable from year to year.

Slide 10:

Debt problem is essentially *unfixable* in a declining economy

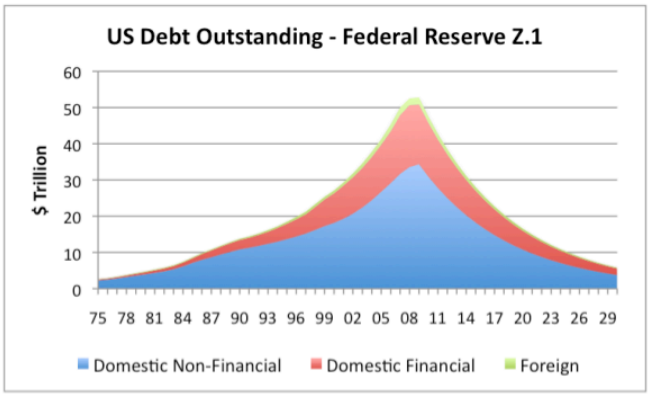
- Loan defaults will always be very high, if economy declining
- High "insurance charge" needed in interest rate
- Resulting high interest rate makes loans unaffordable for most
- Exceptions:
  - Very short term loans
  - Occasional very profitable businesses

It is possible that there will be some loans in a declining economy, but their use will be much less widespread than we see today. Their cost will also tend to be higher.

Slide 11:

Major debt unwind is *still ahead*

- One possible scenario:



When lending is increasing, businesses have more money to invest in new plants and

equipment, and homeowners find it easy to get loans for new homes and for home improvement. When lending is decreasing, the reverse is true.

Slide 12:

Major unwind is still ahead

- Defaults have only begun to occur
  - Likely to get worse in years ahead
  - Will include international defaults
- Bank equity will continue to drop, as more defaults occur
- Interest rates will be higher for those who can get loans

Slide 13:

Major unwind is still ahead

- Effect of unwind likely to be huge
- Adding debt in past allowed us to "borrow from the future"
  - Expanded funds available for investment, major purchases
  - Allowed us to keep up oil drilling, natural gas drilling, coal production, buy cars, buy houses
- Reducing debt will have opposite effect

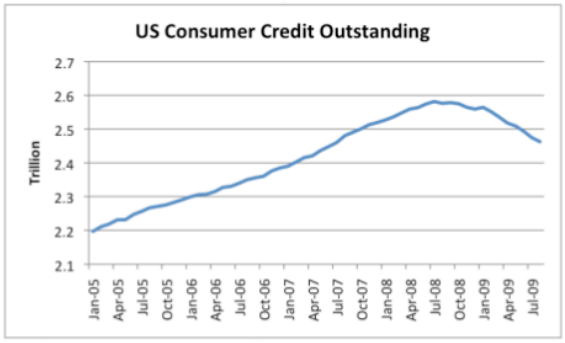
As countries cut back on their stimulus funds, the decline in credit available may be

especially severe.

Slide 14:

Debt unwind has already started

- US consumer credit peaked in July '08
  - Same month as when oil prices peaked



In the US, homeowners used their homes as a piggy-banks when home values were rising. They could refinance their homes, remove the built-up equity, and buy new cars, furniture, and other things. When there are fewer homebuyers (because of less loan availability), and continually declining values, the effect is reversed.

Slide 15:

Debt unwind likely to reduce availability of ***all*** fossil fuels

- Debt unwind means people less able to buy cars, houses, etc.
- Result is less manufacturing, leading to lower ***demand*** for oil, gas, and coal
- Lower demand -> lower prices
- Lower prices -> lower profit margin
- Lower profit margin (and less debt) means less funds for reinvestment -> less fossil fuels

Credit problems are really what are likely to spread the lack of oil to a much broader reduction in fuel use, essentially through growing recession. This recession may affect OECD to a greater extent than non-OECD, but there are such great links between the two that I expect eventually all will be affected. This reduction in fuel use is likely to be described in the press as "reduced demand"--which it is, but because of recession induced by credit contraction (ultimately going back to lack of growth in oil supply).

Slide 16:

Debt unwind also likely to impact nuclear, wind, and solar

- Lower fossil fuel prices make these products less competitive
- Funds available for investment much lower
  - Lack of debt availability
  - Profits available for reinvestment
- Result: All energy products in drastic decline
  - Perhaps low EROI is now being recognized
  - Economy may go into nosedive

Slide 17:

Debt unwind may also lead to *globalization unwind*

- Less oil -> travel more difficult
- Multiple defaults in loans -> less trust of international banking
- Can international banking system be fixed?
  - Everywhere, huge defaults
  - No easy fix: Debt based system no longer works
  - May lead to more bilateral trade (like barter)
  - Amount of international trade drastically reduced

5. IMPLICATIONS FOR THE PROPERTY/CASUALTY INSURANCE INDUSTRY

What does the foregoing analysis suggest as implications for the property casualty insurance industry?

One implication is that the **assumption of independence** used in financial models of all kinds needs to be looked at much more closely than the past. If there is truly systemic risk in the system, caused by limitation on resources that prevents long-term economic growth, this could quite easily spill over into assumptions underlying all kinds of financial models. Clearly pricing of mortgage guarantee insurance and financial guarantee insurance would be affected. Pricing of homeowners insurance might also be affected, if systemic risk results in declining property values relative to replacement values, and thus tends to too low prices for many sub-coverages.

Another implication is that we are likely now in the time-period between two financial crises, and furthermore, that the second financial crisis is likely to be worse than the first. In the first financial crisis, life insurance companies tended to far worse than property casualty companies, for a variety of reasons, including longer term insurance products, riskier investments, and greater leveraging. This analysis suggests that there is a significant chance the property casualty insurance industry will be hit much harder in the next financial crisis than it was in the 2008-2009 crisis.

Based on my analysis, the big issue ahead for property-casualty insurance companies is that default rates on bonds are likely to be very high for many kinds of bonds. For example, municipal bonds are likely to have high default rates, as property values continue to drop, and municipalities find it increasingly difficult to collect enough taxes to meet all of their obligations.

Many of these municipal bonds are insured under financial guarantee insurance contracts; it is very doubtful that the insurance companies writing this coverage can withstand defaults by more than a small percentage of municipalities for which the coverage was provided. At some point, the financial guarantee insurers writing the coverage will become insolvent, and the property-casualty insurance industry may be on its own, in trying to deal with the issue.

There is of course some possibility of a bailout by Washington DC, but with increased federal borrowing, and debt problems around the world (Greece, Portugal, Spain, for example), even such a bailout may become impossible. An alternative bailout would be of all the municipalities with problems, but this would present the same issue of scale.

If the property-casualty insurance industry faces major defaults on bonds on its balance sheet—even those that are currently highly rated—this would likely lead to very significant erosion of insurer equity. Companies are likely to find themselves too highly leveraged,

based on AM Best solvency ratios, and may find it necessary to cut back on amount of insurance sold to meet regulatory requirements. Ultimately, many property–casualty insurers may fail.

Property-casualty post-insolvency assessment funds are not set up to deal with multiple failures of large insurance companies, so here again, the US government may want to step in. But again, there is likely to be an issue of ability to step in, if banks and life insurers are also having financial problems, and US borrowing is already stretched beyond reasonable limits.

If the crisis isn't as bad as to cause major debt defaults, this analysis would suggest it may play out somewhat like the 2008-2009 crisis, with some of the same issues involved. Workers compensation insurers may find themselves with reduced premium volume, but rising claim volume, related to employee layoffs. Insurers of all types are likely to find that exposure volumes are decreasing, rather than increasing, leading to pressure on expense margins. This issue may especially affect brokerage firms.

In the 2008-2009 crisis, reduced investment income was an issue. As default rates rise, one would expect interest rates start rising, reflecting the greater real risk involved in holding bonds. This may be a temporary respite for property-casualty insurance companies. Ultimately, however, rising interest rates can be expected to lead to defaults by more and more borrowers, as they find it impossible to repay debt plus the higher interest rates, in a declining economy.

Over the very long-term, if the economy is in permanent decline, this analysis would suggest that the only coverages that will really be feasible for property-casualty insurance companies are the very short-tail coverages—fire, auto physical damage, marine, etc. To the extent insurance is provided, one would exptect that it reflect a pooling of risk, with little time-shifting, because bonds held on the balance sheet can no longer be counted on for repayment several years later.

Long-term, this analysis would suggest that the financial services industry in general will shrink greatly in the years ahead. Without continued economic growth, pushed by rising energy supplies, debt products that are of more than very short duration can be expected to mostly disappear. Because of this, the whole world of financial services can be expected to greatly contract, including property-casualty insurance.