Risk Management Lessons Worth Remembering

From the Credit Crisis of 2007–2009[1,2]

BLACKROCK

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Abstract This paper presents eight general principles of risk management and eight important lessons worth remembering from the Credit Crisis of 2007–2009. The Credit Crisis has clearly demonstrated the importance of a strong, independent risk management function, and our eight basic principles of risk management will help institutions to craft the foundation of their risk management organizations. The Credit Crisis has also revealed the inadequacy of many standard methods in quantitative risk management and called into question the efficiency of markets in general. Our analysis of these eight lessons from the Credit Crisis provides insights into what went wrong and offers advice on how institutions can attempt to correct for these failings in the future. Detailed analysis is provided on risk management issues relating to liquidity, securitized products, certification, market risk and policy risk.

The Credit Crisis of 2007–2009 has necessitated a rethinking of financial markets in general and risk management practices specifically. Many investors have taken losses well in excess of their expectations, and the subsequent rebound in risk assets that began in the spring of 2009 has resulted in significant underperformance for those with conservative allocations. More distressing has been the near complete loss of liquidity and transparency as large segments of the market literally ground to a halt. Traditional fundamental and technical drivers of risk and return were overwhelmed by the impact of malfunctioning markets and dramatic changes in government policy. The paramount importance of managing liquidity has been demonstrated decisively, and the hypothesis of market efficiency as the sole defining paradigm for modeling and measuring institutional risk has been demonstrably falsified by experience. In light of these observations from the Credit Crisis, best practices in risk management need to be retooled for a world in which global financial markets cannot be assumed to always be open and efficient, and the rules of the game can be dramatically in flux.

The purpose of this paper is twofold: first, articulate eight general principles on the organization and objectives of an institutional risk management process and, second, present several specific lessons worth remembering from the Credit Crisis. The Credit Crisis has shown that many widely used risk management techniques relied on critical assumptions that have turned out to be flawed. Recommendations on the future practice of risk management are made to correct or mitigate the negative impact of relying on these faulty assumptions. Our discussion of these specific lessons worth remembering from the Credit Crisis aims to understand why economic theory and quantitative methods in risk management failed and offers recommendations for what can be done to try to correct for these failures in the future.

This paper does not provide a mathematically oriented review of specific methodological modeling flaws, a topic covered by others. For instance, Taleb (2007b) argues against "the use of commoditized metrics such as 'standard deviation,' 'Sharpe ratio,' 'mean-variance,' and so on in fat-tailed domains where these terms have little practical meaning."[5] Yet neither is this paper a Luddite creed about abandoning quantitative risk management for a more "common sense" risk management process.[6] The goal of this paper is to define general principles of risk management and provide detailed analysis of the lessons worth remembering from the Credit Crisis of 2007–2009.

The enumeration of general risk management principles in this paper is certainly not exhaustive or necessarily innovative; however, each of them represents an essential element of any well thought out institutional risk management program. Moreover, while many of these principles were generally accepted in advance of the Credit Crisis, ensuing events raise doubts about the depth of adherence to risk management principles in practice.

The eight general risk management principles are summarized below and then developed in greater detail in the paper. First, risk management requires institutional buy-in. Second, the alignment and management of institutional interests are critical to risk management. Third, institutions need an independent risk management organization with strong subject-matter expertise. Fourth, institutions need to understand their fiduciary responsibilities to their clients. Fifth, while a top-down perspective is necessary, a bottoms-up risk management process is vital. Sixth, institutions need to get portfolio managers to think like risk managers. Seventh, risk models require vigilance and skepticism. And eighth, institutional risk management does not mean risk avoidance.

Numerous lessons can be gleaned from the Credit Crisis, and undoubtedly, this period will be researched for many years. In this paper, the following eight specific lessons worth remembering from the Credit Crisis are explored in-depth and represent a substantive addition to the eight general principles of risk management outlined above. First, institutions must recognize the paramount importance of liquidity. Second, investors in securitized products need to look through data to the behavior of the underlying assets. Third, institutions must always be cognizant that financial certification is useless during systemic shocks. Fourth, the market's appetite for risk can change dramatically. Fifth, the market's level of risk can change dramatically. Sixth, institutions need to manage their level of risk rather than letting the market determine their level of risk. Seventh, institutions must adapt to the increasing importance of policy risk. And eighth, institutions must always remember that by the time a crisis strikes, it is too late to start preparing for it. While there are undoubtedly many other lessons to be extracted from this period of unprecedented financial disruption and volatility, remembering and addressing these eight lessons from the Credit Crisis will be critical to the future success of institutional risk management.

This paper is organized as follows. The first section describes in detail eight general risk management principles. The second section of this paper then describes eight lessons from the Credit Crisis and offers recommendations for augmenting existing risk management practices to incorporate these lessons. Finally, conclusions are discussed in section three.

1.1 Risk Management Requires Institutional Buy-In

For risk management to be successful over the long term, it must become an integral part of an institution's governance and culture. Inevitably, this can only happen if it is strongly supported at the top of an organization. The particular circumstances of every organization and its management will differ. Senior managements across different institutions may be more or less conservative, experienced, financially sophisticated, longer-term oriented or concerned about the financial livelihoods of their employees or shareholders. To some, risk management is simple common sense. To others, it is seen as a path to value-maximization. To others, it is an ethical principle driven by a sense of duty. To others, it is the only way to sleep at night. To yet others, it may be driven by the desire to avoid reliving previous professional and personal nightmares.

Regardless of the ultimate source of motivation, a demonstrable commitment from the top is required for even the best risk management process to be successful. In practice, this means that an institution will make risk-informed decisions even if they conflict with other pressing objectives. Institutional behavior inconsistent with a risk-oriented mindset will not be rewarded, and hard decisions will be made when the risk culture framework is violated. For instance, if a risk manager finds himself or herself in conflict with a large revenue producer, the actions taken by senior management in resolving the conflict will speak a hundred times louder than simply mouthing slogans but not backing them with action. This does not mean that senior management always has to back the risk managers. The facts of every situation will necessarily differ, but the manner in which the various considerations are weighed is critical. Through their consistent actions over time, they must demonstrate that risk management concerns will be taken very seriously and that the institution will not be governed solely by short-term considerations.

Senior management also has to articulate and enforce clear policies on the role of risk management. These include providing the necessary resources, supporting the development of risk limits, ensuring full and open dialogue across internal organizational boundaries and requiring internal transparency between risk

takers and risk managers. Senior management can also demonstrate their buy-in through less formal means, such as explicitly recognizing and reinforcing the role of risk management through internal communications and making sure that the accomplishments of the risk management teams are broadly recognized within the institution. Even relatively minor internal signals, such as the allocation and location of office space, will speak loudly by making sure that the official ideology is reflected along the various dimensions of the internal institutional pecking order. Without institutional buy-in, even a talented risk management organization will play only a peripheral role and achieve little impact.

1.2 The Alignment and Management of Institutional Interests Are Critical to Risk Management

While it is beyond the scope of this paper to explore in detail the subtleties and nuances of designing organizational incentive structures, to ignore the relationship of alignment of interests and the effectiveness of risk management would be to ignore a material aspect of what drives success or failure in risk management. In many cases, the best risk manager might not be able to make important contributions to the welfare of an institution because, despite vapid "mission statements," the institution does not act in accordance with a common set of goals. For risk managers at such institutions, many of the lessons worth remembering may turn out not to matter because there are powerful constituencies within their organizations that are not necessarily incentivized to look out for the long-term welfare of the institution. In what follows, the micro-economic and cultural aspects of institutional alignment are briefly discussed. A broader topic, the impact of corporate governance models and regulation, are not addressed, although they are clearly very important. But since the specifics of these issues vary quite dramatically across institutions, the focus in what follows will be only on those aspects of an institution that are generally within the direct control of its management.

One of the challenges of any institution is to find ways of maximizing individual performance while tying it all together across the institution in order to maximize the institution's overall long-term effectiveness and welfare. Institutions often have a variety of internal stakeholders, and each of them has interests that may not necessarily align completely with each other. Compensation methodologies with narrowly focused goals tailored to individuals or to organizational sub-units will, by design, tend to maximize the behaviors incentivized by those goals. While incentive focused compensation structures inspire individuals to work hard and produce, oftentimes these efforts can be a detriment to an organization's long-term interest. For instance, it might not be realistic to expect a salesman who is compensated solely on a commission basis to provide the best support to smaller accounts, absent some element of the institution's culture, even if the institution declares that it aims to provide the highest degree of client service. Similarly, a portfolio manager compensated solely on their performance may not choose to participate in the broader objectives of the institution, like training junior professionals, again absent some element of the institution's culture. To the extent that an institution is organized in a manner that narrowly focuses its incentives to the specific tasks and goals of particular stakeholders, it may end up that it is economically rational and even highly predictable that the internal stakeholders will tend to pursue different agendas that could very well conflict with each other and the institution's long-term welfare. In these types of institutions, the risk manager's job will be more challenging since he will have to design a range of processes to manage the (potentially) excessive pursuit of certain objectives to the detriment of the overall institution's welfare.

In contrast, when internal policies and incentives can channel behavior in a common direction, the task of the risk manager is simplified. Equitably shared common bonus pools, compensation programs that reward longer-term performance and employee equity ownership are all steps that tend to synchronize behavior. While there are a host of details that need to be carefully tuned to a particular institution's activities, by pursuing this path, the institution will tend to have less internal dissonance. However, the lack of internal dissonance does not necessarily map to the long-term welfare of the institution. For instance, a single-minded focus on sales or earnings growth may lead to excessive levels of risk being demanded by portfolio managers. In such a case, the common goal is clear to all internal constituents; however, that goal may lead the institution lock step off a cliff.

The ideal case is when the common direction of individual constituents is also rationally aligned with the long-term welfare of the institution itself. This requires a careful balancing of individual and collective incentives in order to generate the optimal tradeoff between individual performance and the collective interests to make the institution both efficient and robust. There is not an obvious formula for this. Executive management's job is to constantly be working to balance these two conflicting institutional incentives. When this is (approximately) achieved, the risk manager's job becomes significantly easier because the various internal constituencies are heading in the same general direction, and that direction is sober and prudent.

The previous discussion on the importance of aligning interests has focused on the micro-economic incentives inside an institution. Perhaps this is the area where the authors, like most economists, are most comfortable. However, experience and casual empiricism have demonstrated that an institution's culture can provide an exceedingly powerful force for alignment that can mitigate the inevitable internal dissonance that an institution with many different internal constituencies can create. To be succinct, different cultures will lead to a different degree of focus on either expanding the pie or fighting about how big a slice of the existing (or even smaller) pie goes to each stakeholder. Properly done, an institutional culture of faith and loyalty becomes an extremely powerful and important tool for aligning individual and institutional interests and reducing the risk of stakeholders aggressively pursuing interests contrary to those of the institution.

From this perspective, an institution's culture should ideally create a common sense of purpose and shared interests among all the internal stakeholders. That common sense of purpose may arise from a well understood common set of values, a long operating history with emphasis on critical decisions that iconify the commitment to those values or even a powerful "founding myth" which provides a particular view of how and why the institution came into existence. This necessarily goes beyond the repetition of empty platitudes and must be consistent with how the institution is run on a day-to-day basis and how it treats its people. When the operation of an institution and the treatment of its people are consistent with a common sense of purpose, then an institution can move in a unified direction even if that direction is sometimes inconsistent with individual stakeholder's narrow interests.

However, a common set of values only has meaning if the institution has the ability to execute them effectively. Thus, being well run is a necessary condition for an institution to be a vehicle for the transmission of those

values. Again, there are a host of theories on what makes an organization well run that go beyond the scope of this paper, but amongst those most important from a risk management perspective are:

- Relatively flat hierarchy—senior management is seen as being abreast of what is actually happening across the institution;
- Trust/credibility—stakeholders believe in the intentions of the institution;
- Non-bureaucratic—stakeholders believe that things can get done within the institution;
- Non-political—stakeholders believe that the institution is a meritocracy and that individuals will be judged fairly based on their contributions;
- Good internal communications—stakeholders must believe what the institution says and to the extent that the institution is perceived to be disingenuous or incompetent, cynicism will arise; and
- Common information and transparency—to the maximum extent appropriate and permissible, stakeholders should be able to have access to shared information about the institution's operations so that there is a common source of trusted information. By empowering stakeholders, institutions permit them to understand the tradeoffs faced by the institution. This culture of openness will facilitate the surfacing of bad news from the bottom up in an expedited manner. An open and honest institution will empower information to percolate up throughout.

By demonstrating over time and under a range of challenging situations that it is committed to doing the right thing and treating its stakeholders fairly, an institution can build respect, loyalty and a common set of purpose from its stakeholders. This does not mean that the institution cannot or should not make hard decisions. For instance, economic distress may require that the institution downsize. However, the way this is handled, including the fairness of the process for determining which employees are to be let go and the manner in which they are treated, both financially and as individuals, will create the basis for the respect required to encourage stakeholders to put their faith in the institution's values. To the extent that an institution can do this, it will create bonds of loyalty with individual stakeholders that will motivate them to value not only their own narrow self-interests but to pay attention to issues that are in the institution's long-term welfare. If stakeholders believe in the institution, then they will have a greater motivation to preserve and protect it, and that, in a nut shell, is the same mission of risk management.

1.3 Independent Risk Management Organizations

The third general principle addresses both the need for a risk management orientation within an investment operation and the very nature of how a risk management organization should be set up within an institution. While it is ideal for the risk takers to have a strong risk orientation, risk managers cannot provide effective checks and balances unless they are truly independent from the risk takers. This holds true even when the risk takers are highly risk aware, such as the case with explicitly quantitative investment processes that optimize expected return subject to formal risk constraints. The independent risk manager needs to be able to look at the entire investment process with the critical eye that can only come from organizational independence.

The Credit Crisis of 2007–2009 has clearly demonstrated the necessity of having a strong, independent risk management function. For instance, there have been accusations that Washington Mutual, Inc. (WaMu), which was seized by the Office of Thrift Supervision (OTS) in September 2008, ignored, marginalized

and possibly even fired risk managers who raised concerns about the bank's mortgage lending practices.[7] The authors are aware of numerous instances where risk management teams exist primarily because clients, auditors or regulators have demanded that they exist, although in practice these risk organizations are at best peripheral or, in some cases, totally irrelevant to the investment processes of their institutions. In contrast, Walker (2009) argues that commitment to a strong risk management process on the part of JP Morgan's chairman and chief executive, Jamie Dimon, helped that firm to weather the Credit Crisis much better than many other financial firms. Similarly, institutions such as BlackRock, where risk management was explicitly part of its founding idea and where it remains an integral part of the investment process, have been able to successfully respond to a broad range of market gyrations.[8]

Independent risk management means, at a minimum, that the risk management group reports up the organization directly to the top of the institution and is not subordinate to the investment functions. Thus, the head of an independent risk management organization should ideally report to the chief executive officer or president of his or her organization rather than to its chief investment officer. The risk organization's compensation structure should also be configured so that risk managers are incentivized solely by the long-term success of the organization and certainly not the short-term performance of the investment portfolios.[9]

Independent risk management functions need not mean that the risk managers function primarily as internal institutional "policemen" who monitor and constrain the behavior of the risk takers. While organizations need to have "eyes and ears" into their risk-taking activities, we argue that there is often much more efficacy in having the risk functions working closely and collaboratively with the risk takers. This approach has two significant advantages. First, the risk managers' efforts are primarily directed toward improving the risk awareness of the investment process rather than functioning in a detached and explicitly confrontational role. This makes the risk manager valuable to the investment team as a value-added provider of subject-matter expertise, as well as a source of additional resources. The second advantage of this approach is that it necessarily puts the risk manager more directly into the flow of the investment team's decision-making process and, as a result, much more aware of what is actually happening. Thus, rather than being off at a distance and struggling to understand the context of the investment process, the independent, but embedded, risk manager is directly involved in the process.

For this approach to work, the embedded, independent risk manager must have substantive subject-matter expertise, good interpersonal skills and be a strong self-starter. These skills will aid the embedded independent risk manager in gaining the respect and acceptance of his or her investment management colleagues. However, in spite of these skills and this vantage point, if the embedded independent risk manager is ultimately unsuccessful in educating or persuading the risk takers about material concerns associated with the risk of their portfolios, they are well placed to provide input up the line of the risk management organization. These concerns can then be addressed either by bringing in additional expertise from more senior risk managers to work with the risk takers or, if still unsuccessful, to escalate the concern further up the institution to a final resolution.

Nevertheless, it needs to be pointed out that this form of organizational structure is not without its own issues. The independent reporting line and compensation structure should ideally allow the risk manager to remain independent, in reality, however, the day-to-day environment in which the risk manager operates can

sometimes "capture" the "heart and mind" of the embedded risk manager. The end result is that the risk manager becomes just another quant for the investment team, rather than a source of independent perspective on portfolio risk.

This organizational challenge must be actively managed by the independent risk management organization. Competitive compensation, mature risk managers, regular risk team meetings, a strong risk culture and attentive oversight of line risk managers are all critical devices to make sure that the embedded risk manager does not become, in effect, just another member of the investment team. Even seemingly minor issues, such as the advantages of deeper subject-matter expertise gained from longer tenures working in a particular market, need to be balanced against the advantages of rotating individual risk managers between portfolio management teams in order to facilitate and maintain independent perspectives. Similarly, the desire to have independent embedded risk managers seated with the investment teams needs to be balanced against the increased risk of "capture" that occurs when risk managers are not seated together. We are aware of some risk managers who choose to keep their entire risk management team in close physical proximity to each other to mitigate capture, whereas others seek to have small embedded "pods" of independent risk managers live within the sea of portfolio managers. While it is hard to draw specific guidelines to achieve the "optimal level of embeddedness," the tradeoff between enhanced knowledge of positions and risks versus risk of capture must be a constant focus of senior risk managers. A strong and independent risk management organization is essential to the future success of any institution.

1.4 Define Your Fiduciary Responsibilities

Each type of institution has its own ultimate beneficiaries to whom the managers have a fiduciary obligation. For a pension fund, the fiduciary obligation protects the plan beneficiaries. For an investment manager, it protects the clients. As the fiduciary of a nation's wealth, the responsibilities of sovereign wealth funds are directed to their societies.

In the midst of the Great Depression, Stone (1934) clearly articulates this principle, and his words are a testament to their permanence.

> I venture to assert that when the history of the financial era which has just drawn to a close comes to be written, most of its mistakes and its major faults will be ascribed to the failure to observe the fiduciary principle, the precept as old as holy writ, that "a man cannot serve two masters"... financial institutions which, in the infinite variety of their operations, consider only last, if at all, the interests of those who funds they command, suggest how far we have ignored the necessary implications of that principle. The loss and suffering inflicted on individuals, the harm done to a social order founded upon business and dependent upon its integrity, are incalculable.

Without knowing the desired objectives for your fund, and your tolerance for volatility, risk cannot be managed effectively. Moreover, simply noting that your fund's lack of clarity in its fiduciary responsibility is no more egregious than that of other funds offers no solace either. In fact, as the Credit Crisis and past crises have shown, the impact of neglecting fiduciary responsibilities are exposed most dramatically when risks are at their highest.

While defining the appropriate objectives of a fiduciary can be challenging, those objectives need to ultimately be communicated to the institution's internal and external investment managers. For those investment managers, the following basic questions must be answered. What is the target return of the fund? What level of risk can the fund tolerate? Which classes of securities are permissible, and what limits should be placed on portfolio construction? Oftentimes, the answer to these questions can be formally structured through the provision of an investment benchmark combined with active return targets and expected risk levels. While the questions themselves are simple, acquiring, understanding and sharing the answers to these questions requires time and resources, particularly if the manager is responsible for multiple clients whose assets are directed for differing purposes. In order to execute effective risk management, sufficient time and resources are required to define your fiduciary responsibilities and then structure an investment and operational process that maintains ongoing focus on those goals. Without clear definitions and goals, it will be nearly impossible to manage the exposures and events that put at risk the assets of those stakeholders to whom institutions owe their primary fiduciary responsibility.

1.5 Bottoms-Up Risk Management

In a world of increasingly complex and diverse investment securities and their derivatives, effective risk management must incorporate a bottoms-up approach. Risk management requires that you intellectually "get your hands dirty." Many risks lurk in the details, especially those that arise suddenly. Risk management organizations must invest in the subject matter expertise required to identify the risks of each security/derivative and then aggregate them up to the portfolio level. A primarily top-down risk management approach generates risk assessments based on gross assumptions that may mask critical risk attributes of securities or derivatives. Such approaches necessarily must rely either on stylized facts or integrative risk models. As such, they work only when the underlying assets behave either as believed or as modeled. In some cases, top-down risk management can actually become almost aspirational, as the expectations of the institution begin to shape its view of its investment risks. Unfortunately, these expectations are often proven naïve or just plain wrong, and there have been more cases than bear repeating where institutions simply did not understand the risks of their portfolios. Hence, effective risk management requires assessments based on highly granular facts. Bottoms-up risk management based on intensive subject-matter expertise is the only way to deliver accurate assessments.

In order to conduct bottoms-up risk management, an institution needs to know what it owns and where it owns it. This is common sense and easy to simply assume. The reality is that for many institutions, constructing an enterprise-wide inventory of positions and exposures remains a significant challenge due to organizational reasons and the limitations of internal information systems. In addition, the specific details of each asset need to be known. Even in the case of explicitly top-down asset allocation investment strategies, the risk manager needs to understand the details of the instruments chosen to implement the top-down views. For example, if future contracts or derivatives are used, the precise terms and conditions of those instruments need to be studied carefully. Simply knowing the general characteristics of a class of securities will not suffice, since under stressed conditions, the nuances of each particular product can have profound implications. Securities need to be reverse-engineered so that the parts that make up the whole can be fully understood.

In the equity space, bottoms-up risk management includes the traditional fundamental research combined with close attention to market, style, industry and idiosyncratic risk exposures. In fixed income, this includes not just monitoring factor exposures and fundamental credit analysis but also all of the financial engineering

on top of it. Each asset and liability associated with a portfolio needs to be modeled in a micro-analytically correct manner. Only after each individual security is appropriately defined, and its exposures are modeled and measured, can those exposures then be aggregated to portfolio-level risks. Deriving aggregate risks from bottoms-up risk management is difficult, takes time and is expensive. However, this type of process results in risk assessments that are based on facts rather than assumptions or, in many more unfortunate cases, blindness.

1.6 Get the Risk Takers to Think Like Risk Managers

Ultimately, risk management needs to focus on increasing the overall effectiveness of portfolio managers. Risk management principles should be fully integrated into the investment process of the risk takers. In order to have any impact, risk assessments must make their way into the decision making of the risk takers. Thus, to the extent that independent, embedded risk managers are successful, they help push forward the institution's "first line of defense." This can be thought of as the "lazy risk manager's approach" to risk management because if the risk takers are thinking about their own risks properly, then the risk managers should ideally not have to do very much. If the risk managers effectively communicate how they see the world, then the risk takers can work to make the appropriate risk-versus-return tradeoff. Conceptually, this is a trivial point. In practice, it can be quite challenging. First, the risk manager must make sure that the portfolio manager has identified all the relevant risk drivers. Then, the risk manager needs to make sure that the portfolio manager has access to accurate, timely and comprehensible ex-ante metrics so that the portfolio manager has an appropriate risk dashboard.

While the existence of such a dashboard is a necessary condition for success, it is not sufficient. In practice, it may turn out that, absent direct involvement, the portfolio manager may not be able to fully and appropriately use the dashboard. In effect, the goal needs to be that the portfolio manager has the ability to translate his or her views of the market into an efficient portfolio that reflects those views without the creation of material amounts of inadvertent risk. In order to do this, risk managers must own the burden of translating their insights into actionable items. As best stated by a senior investment professional, "it is essential that the experts, who understand the necessary complexity of the risk that big and diversified firms take, can somehow manage to communicate their messages effectively to people who have other responsibilities."[10]

1.7 Risk Models Require Constant Vigilance and Skepticism

In order to be tractable and useful, risk models necessarily must simplify the characteristics of a very complex and fast-changing world. However, that simplification comes at the cost of accuracy and structural integrity under stress. Hence, given their known limitations, risk models and financial analytics always need to be monitored for their effectiveness and relevance. The underlying assumptions residing in models should be constantly assessed to see if they still hold true, and if not, what the impact will be for the models that use those assumptions.

Market risk models are necessarily sophisticated heuristics since the underlying "system" being modeled is economic and, hence, adaptive to the economy's knowledge of the model and its use by market participants. Moreover, any model is an abstraction of an infinitely more complex reality and the phenomena being modeled may only represent a small and even potentially insignificant part of the potential losses. Taleb's "Ludic Fallacy" highlights the potentially dangerous tendency to objectify a risk into a defined paradigm which cannot capture the true risks of concern.[11] In plainer language, the "risk" is that the risk manager may effectively confuse the expected behavior of the model with the realities of the market. Financial markets do not represent

a giant video game where the actions and relationships are predetermined by a finite set of known rules. However, staring at computer screens all day and analyzing models that are governed by static code can easily lead to a level of detachment and false sense of confidence that the artificial world created in our risk models adequately captures the real world we are seeking to understand. Risk managers have no choice but to define a model, fully knowing that it will be incomplete and inaccurate. They, therefore, must make an ongoing effort to understand when and why models "stop working." Too often model complexity is increased, while it is the model's basic assumptions that need to be re-examined.

At the same time, risk managers must be very conscious of the cult of "science" and expertise that can radiate from the use of mathematically sophisticated risk models which might be in excess of the model's predictive powers. While bona fide risk practitioners generally understand many of the limitations of their models, there remains a challenging balance that needs to be maintained between, on the one hand, overselling the certitude available from the proper use of these models, and identifying all the model's weaknesses and ending up providing grist for those in an institution who are either uncomfortable with the reliance on domains of knowledge outside their own expertise or, more likely, those who have a vested interest in diminishing the constraints associated with the use of the models. To the extent that the institution has a constructive culture and an alignment of interests, this challenge can be managed, but it requires constant attention and balancing.

Financial markets are constantly changing. The very existence of a widely understood risk model will necessarily change the overall characteristics of the system. Hence, risk analytics and processes need to be constantly reviewed and reinvented. Risk managers will continually be fighting the last war if models are only re-evaluated after they break down catastrophically. Risk managers must, therefore, also stay abreast of current research and practices.

1.8 Risk Management Does Not Mean Risk Avoidance

A necessary condition for generating returns in the absence of arbitrage is risk taking. The goal of risk management is thus two-fold. First, make sure that only desired types and levels of risks are taken while undesired risks are avoided. Second, the size of the risks that are taken need to make sense given the size of the target return. If that can be achieved, investors can, in many cases, have increased confidence to act more decisively in their active portfolio positioning. In particular, risks can be positioned more precisely to incorporate the particular "bet" the investor seeks without creating ancillary exposures that have the potential to pollute the original insight driving the investment decision.

The degree of risk taking needs to be tempered by the inherent uncertainty in risk measurement, common sense and some basic humility. Recent events have highlighted how this was abused most recently during the Credit Crisis of 2007–2009. Among the many examples of this abuse was the accumulation of massive amounts of super-senior collateralized debt obligation (CDO) risk by investment banks who had the strongest levels of convictions that they understood the risks of these positions and that they were minimal.[12] Obtaining institutional buy-in, aligning institutional interests, creating a truly independent risk organization, defining your fiduciary responsibilities, knowing what you own, conditioning the risk takers to act like risk managers, monitoring your models and taking only the risk you want to take are basic principles of risk management. They were true before this crisis and will continue to hold true in the next crisis. These eight principles should form the foundation of any institution's risk management organization.

2. Lessons Worth Remembering

The previous section described eight basic principles of risk management. It is from this starting point that the impact of the market turmoil is evaluated. This section outlines eight important lessons worth remembering from the Credit Crisis of 2007-2009. Institutions need to incorporate these lessons into their risk management processes in order to successfully navigate, and perhaps even prosper, when comparable events arise in the future. These lessons are worth remembering even at the risk of preparing to "fight the last war."

2.1 The Paramount Importance of Liquidity[13]

Liquidity is the life blood of commerce, and the ability of institutions to meet their immediate cash obligations is critical to their financial survival. There are at least two distinct but relevant and interconnected definitions of liquidity. As articulated by the Basel Committee on Bank Supervision (2008).

> *Funding liquidity risk* is the risk that the firm will not be able to meet efficiently both expected and unexpected current and future cash flow and collateral needs without affecting either daily operations or the financial conditions of the firm. *Market liquidity risk* is the risk that a firm cannot easily offset or eliminate a position at the market price because of inadequate market depth or market disruption.

During the Credit Crisis, liquidity evaporated from large segments of the fixed income and commercial paper markets for extended periods of time. The catalyst for the return of liquidity to some of these markets, in many cases, has been primarily the result of specific government programs that either provided explicit credit guarantees or incentives to certain investors to purchase assets, such as, in the US, the Term Asset-Backed Securities Loan Facility (TALF) and the Public-Private Investment Partnership (PPIP). While some of these government programs are being unwound, many of these programs continue to be in place as of the writing of this paper.[14]

Many market participants lost sight of the paramount importance of liquidity and, as a result, suffered greatly. To some extent, this failure of institutions to manage liquidity was due to complacency and irresponsibility. However, the lack of appreciation for the importance of liquidity was also in large part due to an inadequate conceptual framework. For at least the last 30 years, markets have generally been exhibiting increasing degrees of liquidity as improvements in finance theory, market infrastructure and the dramatic fall in the costs of computation, data storage and data communications has made transactions quicker and easier.[15] For instance, exchanged traded equities have moved from trading in eighths to sixteenths to decimals, and the abundance of short-term funding liquidity allowed leverage at investment banks to rise from less than 12 to one to as high as 40 to one in the run-up to the Credit Crisis.[16] Nevertheless, the Credit Crisis of 2007-2009 has proven that without the necessary liquidity, nothing else matters. Forecasting the synchronous shortening of investment horizons that drove much of the liquidity crisis is hard if not impossible; hence, the need for institutions to actively plan for the potential loss of liquidity is vital. As such, below we discuss six distinct lessons worth remembering from the Credit Crisis specifically related to the issue of liquidity.

2.1.1 Price ≠ Intrinsic Value—Unless Special Conditions Hold

The cornerstone of academic finance for 40 years has been the efficient-market hypothesis (EMH), as described in Fama (1965) and Samuelson (1965). In well functioning markets, the search for arbitrage opportunities should generally lead prices to approach the market's best assessment of intrinsic value.[17] The argument, first put forward by Milton Friedman (1953), is that prices cannot deviate substantially from intrinsic value for long because arbitrageurs will always step in and keep exploiting any such mispricing until it disappears. The arbitrageurs are assumed to ultimately win out over naïve investors because the naïve investors eventually go broke due to their poor investment decisions.

In the past 20 years, however, research in finance has focused on the "limits to arbitrage."[18] In these arguments, funding liquidity constraints force the arbitrageurs to go broke long before market prices return to intrinsic value. These constraints include the inability to short sell, short investment horizons and the existence of systematic, directional noise trading. During the Credit Crisis, several seemingly obvious arbitrage opportunities failed to be exploited. These included pre-refunded municipal bonds trading at higher yields than (taxable) US Treasuries of similar maturities, negative 30-year interest rate swap spreads and special purpose acquisition companies (SPACS) that had not yet made a single acquisition but traded at a significant discount to the cash on their balance sheets.[19]

While arguments can certainly be made that the examples above are not necessarily definitive violations of the EMH (i.e., liquidity premia, asymmetric information, etc.), the Credit Crisis has demonstrated that markets can break down so dramatically that market prices simply do not even exist for extended periods of time! If there is a sustained lack of bids on a valuable asset, the nuances of market efficiency become somewhat irrelevant.[20]

Much of these occurred in the over-the-counter markets where the vast majority of fixed income assets are typically traded. There are literally millions of tradable fixed income securities. On a given "typical" (i.e., pre- or post-crisis) day, some of these securities, like on-the-run Treasuries, will trade thousands of times a day. Others, like corporate bonds, might trade sporadically over the course of a day. Yet others might trade every few days, while some might never trade at all.[21] As a result, it is almost never the case that fully synchronous prices exist for the bond markets. Typically, most bonds are priced intraday "off" one or more liquid instruments, such as an on-the-run Treasury or interpolated Treasury curve, an interest rate swap or swap curve, a credit default swap or an interest rate option or implied volatility surface. Thus, when seeking the value of a bond, investors would generally rely on direct quotes from broker/dealers, "indications" of value from broker/dealers who are not making a firm offer to buy or a third-party pricing service that would "price" bonds by determining an indicative pricing matrix garnered from discussions with broker/dealers about bond spreads off more liquid sectors of the market. During the Credit Crisis, though, the authors became aware, through their interactions with industry peers, of the increased use of "pricing" or "valuation" committees by asset managers as the veracity of "published" prices broke down. What is the market value of an asset that does not trade? During the Credit Crisis, published prices from third-party pricing vendors for many securities were materially greater than the levels that could be obtained from the markets assuming any price was executable at all.

The valuation problem is not as simple as it might appear to those who view the financial world through the lens of large-capitalization stocks on the New York Stock Exchange or other public exchanges. In fact, the accounting profession felt the need to provide detailed guidance on how to value assets precisely when markets are not active. In a real-time market for securities with lots of available information, it is, of course, hard to reconcile the EMH with an inactive market. In the US, the Financial Accounting Standards Board (FASB) (2006, 2008) Statement of Financial Accounting Standards (FAS) No. 157 required 128 pages to come up with a framework to value assets in inactive markets. In FSP FAS 157-3, issued on October 10, 2008, right in the middle of the Credit Crisis, the FASB Staff Position "clarified" the notion of price (i.e., fair value) "when the market for that asset is not *active* (italics added)."[22]

> A fair value measurement represents the price at which a transaction *would occur* between market participants at the measurement date. As discussed in Statement 157, in situations in which there is little, if any, market activity for an asset at the measurement date, *the fair value measurement objective remains the same, that is, the price that would be received by the holder of the financial asset in an orderly transaction (an exit price notion) that is not a forced liquidation or distressed sale at the measurement date.* Even in times of market dislocation, it is not appropriate to conclude that all market activity represents forced liquidations or distressed sales. However, it is also not appropriate to automatically conclude that any transaction price is determinative of fair value. Determining fair value in a dislocated market depends on the facts and circumstances and may require the use of significant judgment about whether individual transactions are forced liquidations or distressed sales.

The FASB argues that even in an inactive market with forced liquidation and/or distressed sales a notion of "fair" value still exists, and that value may be materially different than observed market prices. However, the FASB also asserts that the existence of a market dislocation does not necessarily invalidate the information content of observed prices. It is fair to say that the need for such "clarification" from the FASB demonstrates the level of turmoil and disorder in the markets.

The FASB categorizes assets into three categories depending on the confidence associated with their valuation. Level 1 assets are assets that are readily traded and whose prices are directly observable; Level 2 assets are assets that are priced based upon readily observable market quantities; and Level 3 assets are assets for which no observable or comparable market prices exist. To put the magnitude of the valuation problem into context, consider the massive growth of Level 3 assets during the Credit Crisis. As of the fourth quarter of 2008, financial companies in the S&P 500 had nearly $537.4 billion of Level 3 assets. For a sense of perspective, note that the total market capitalization of S&P 500 financial companies at the end of 2008 was $598 billion. Now, it is certainly true that the value of these assets could be much less than their reported value of $537.4 billion. However, it is also true that the value of these assets is certainly not zero, yet these assets have no readily observable price. Without a market price, financial markets cannot clear and asset sales cannot be used to turn wealth into cash regardless of their intrinsic value. The failure to account for the risk of an asset's value becoming unobservable can be devastating.

Therefore, while it is not appropriate to abandon the concept that on many, if not most, occasions markets will exist with pricing that is a decent estimate of the intrinsic value of an asset, it is equally inappropriate and downright imprudent to permit a financial institution's objectives and viability to become hostage to the assumption that an open and efficient market will be waiting for it at all times. Institutions need to pay close attention to their vulnerability to a failing market and take concrete steps to limit this exposure. One of the best ways to do this is by being highly attuned to the cash flow requirements of its underlying liabilities to its various creditors and beneficiaries.

2.1.2 Cash and Cash Flow Are the Only Robust Sources of Liquidity

Arguably one of the best analogies used to describe a liquidity crisis is that "liquidity is like oxygen—you really notice how much you need it once it is gone."[23] If an institution's assets and liabilities are perfectly structured, securities do not need to be sold to raise cash. Regardless of market conditions, positions could always be held to maturity. In this case, (funding) liquidity risk ceases to be an important concern. However, the Credit Crisis revealed that many institutions did not structure their portfolios with sufficient attention to the cash

flow requirements of their liabilities. This meant that portfolios needed to be able to generate cash through the use of markets to sell assets. However, as discussed in the previous section, the risk of relying solely upon this market mechanism can be at times so onerous as to put an institution in jeopardy. The only consistently reliable way to meet demands for cash is through portfolio cash flow, reserves of cash or highly liquid securities.

This does not mean that institutions did not make forward cash flow projections, but rather that those projections may not have properly distinguished the certitude of the forecasted asset cash flow being generated. Not all portfolio holdings have equally reliable cash flows, and the Credit Crisis highlighted the dangers of confusing projected cash flows from well-defined and reliable cash flows. Examples of securities that can generate this cash flow consistently and reliably are high-quality fixed income coupon and principal payments. Other forms of portfolio cash flows, such as cash dividends or distributions from private partnerships, were revealed to be much more variable. This lesson is embodied to large extent in "Principle 1" of the "Principles of Sound Liquidity Risk Management and Supervision" of the Basel Committee on Banking Supervision (2008; P.9). The principle is sound, and it is totally appropriate to substitute the phrase "financial institution" for "bank" and have a universally applicable principle.

> Principle 1: A bank is responsible for the sound management of liquidity risk. A bank should establish a robust liquidity risk management framework that ensures it maintains sufficient liquidity, including a cushion of unencumbered, high-quality liquid assets, to withstand a range of stress events, including those involving the loss or impairment of both unsecured and secured funding sources.

The Credit Crisis demonstrated unequivocally that it is folly to assume that markets will always be available to provide required liquidity. Just as it would be highly imprudent to run a critical care medical facility without a backup electrical generator, it is imprudent bordering on malfeasant to run a financial institution in a manner dependent on the continuously available liquidity from the markets. Many investors, who grew complacent because market liquidity was assumed to always be available, learned this lesson the hard way.

One way to think about the conceptual problem faced by many institutions is that their asset allocation and risk models did not penalize illiquid securities sufficiently. These models do not generally make a distinction between the prices of securities that can be easily converted into cash using the market and those that cannot.[24] Anyone that has gone through the process of obtaining month-end marks for fixed income and alternatives securities knows that widely quoted prices are more like appraisals than actual conversion-to-cash prices. Moreover, standard techniques in portfolio optimization tend to compound problems. Portfolio optimizers typically recommend placing sizeable allocations in illiquid securities because state-of-the-practice risk models are unable to distinguish between prices for US Treasuries (which actually are conversion-to-cash prices) and dealer marks for illiquid securities (which are more like appraisals and could differ substantially from conversion-to-cash prices).

A prime example of this problem is the endowment investment model popularized by the head of Yale University's endowment, David Swensen. Swensen (2009) advocates large allocations to illiquid asset classes, such as real assets, hedge funds and private equity. A breakdown of Yale endowment's asset allocation is listed in

Table 1 below. Over the last five years, Yale's endowment has averaged only a 12.3% and 4.4% allocation to the traditional, liquid asset classes of US equity and fixed income. However, Yale's allocation to illiquid absolute return, real asset and private equity strategies has averaged 67.2%. Moreover, by 2008, Yale's endowment was even running a slightly leveraged portfolio with a -3.9% allocation to cash.

Table 1: Yale Endowment's Asset Allocation (in %)[25]

	6/30/2008	6/30/2007	6/30/2006	6/30/2005	6/30/2004
Liquid Assets	25.4	31.0	32.5	34.6	40.5
US Equity	10.1	11.0	11.6	14.1	14.8
Fixed Income	4.0	4.0	3.8	4.9	7.4
Non-US Equity	15.2	14.1	14.6	13.7	14.8
Cash	-3.9	1.9	2.5	1.9	3.5
Illiquid Assets	74.6	69.1	67.5	65.5	59.4
Absolute Return	25.1	23.3	23.3	25.7	26.1
Private Equity	20.2	18.7	16.4	14.8	14.5
Real Assets	29.3	27.1	27.8	25.0	18.8

Swensen (2009) advocates large allocations to illiquid strategies primarily for two reasons. First, according to Swensen, investors typically "overpay" for more liquid securities, and second, finding top managers in illiquid asset classes is easier and offers greater returns than searching for top managers in liquid asset classes.[26] The ability of Yale's endowment to generate above-market rates of return cannot be questioned. As of June 30, 2008, Yale's endowment had a 15.9% annual return over the last 20 years and a 16.3% annual return over the last 10 years.[27] These large returns enabled the endowment's revenue contribution to grow from $45 million and 10% of total revenues in 1985, to a projected $1.15 billion and 45% of total revenues in 2009.

Unfortunately, during the Credit Crisis, illiquid assets experienced large negative returns. Further compounding problems was that Yale's endowment ran into even more difficulties generating cash at exactly the same time the demands for cash from the Yale University budget were at their highest. The problems at Yale and other asset managers that subscribed to Swensen's endowment model is that high returns do not equate to adequate liquidity. As Bhaktavatsalam and Wee (2009) note, "investment losses since September have forced colleges such as Harvard and Yale to freeze salaries, delay construction projects or borrow money to meet their budgets." In addition to the liquidity problems at Yale and Harvard, several other institutions have also ran into liquidity problems during the Credit Crisis. Table 2 below lists 16 universities, colleges and non-profits that according to Moody's have issued taxable bonds during the Credit Crisis for liquidity purposes. On average, liquidity-related bond issuance increased total debt levels by 68% and the median increase in total debt was 34%.

Table 2: Liquidity Bond Issuance by Universities, Colleges and Non-Profits[28]

Issuer Name	Par Amount	Purpose	Debt Outstanding	Increase in Debt	Date
University of Notre Dame	$100,000,000	Liquidity	$671,000,000	18%	Dec-08
Amherst College	$100,000,000	Liquidity	$320,000,000	45%	Jan-09
Duke University	$500,000,000	Liquidity	$2,000,000,000	33%	Jan-09
Princeton University	$1,000,000,000	Liquidity	$2,500,000,000	67%	Jan-09
Vanderbilt University	$250,000,000	Liquidity	$1,900,000,000	15%	Feb-09
Cornell University	$500,000,000	Liquidity	$2,000,000,000	33%	Mar-09
Emory University	$250,000,000	Liquidity	$1,960,000,000	15%	Mar-09
George Washington University	$200,000,000	Liquidity	$746,000,000	37%	Mar-09
Johns Hopkins University	$400,000,000	Liquidity	$1,460,000,000	38%	Mar-09
Stanford University	$1,200,000,000	Liquidity	$2,600,000,000	86%	Apr-09
Pepperdine University	$50,000,000	Liquidity	$220,000,000	29%	May-09
Nature Conservancy	$100,000,000	Liquidity	$313,000,000	47%	Jun-09
Andrew W. Mellon Foundation	$230,000,000	Liquidity	$274,000,000	523%	Jun-09
Dartmouth College	$250,000,000	Liquidity	$975,000,000	34%	Jun-09
Howard Hughes Medical Institute	$600,000,000	Liquidity	$1,260,000,000	91%	Aug-09
Brown University	$100,000,000	Liquidity	$598,000,000	20%	Aug-09

It is unlikely that the cost of this real financial distress will be deducted from the posted returns of the Yale endowment or the endowments at other universities, colleges and non-profits. However, given that Yale University and other institutions were forced to become the defacto providers of liquidity, in place of their endowments, some performance adjustment is most likely warranted in trying to assess the relative performance of Swensen's endowment model relative to other investment strategies. The market will not always be available to turn wealth into cash especially for illiquid asset classes. Risk managers must always remember that cash, reliable cash flow and unencumbered highly liquid assets are the only robust sources of liquidity, and they need to manage this risk like any other.

2.1.3 Complexity and Opacity Matter More Than You Think

In well functioning markets, arbitrage should push prices toward intrinsic value. However, arbitrage relies upon the presence of expert investors who actually know what the intrinsic value is. An interesting result of prices being near intrinsic value is that many investors can now gain the benefits of diversification by taking positions without necessarily being experts in those securities. In essence, market efficiency enables non-expert investors to free ride the expert investors. The result is that liquidity will tend to be higher when prices hover around intrinsic value for sustained periods of time as non-expert investors enter to take advantage of diversification opportunities.[29]

When severe market dislocations occur, many expert investors will be knocked out of the market because their exposures to the assets in question are typically the largest. In complex and opaque markets, the number of expert investors tends to be small. Many of the asset classes most severely impaired during the Credit Crisis were exceedingly complex. They required large databases that were regularly refreshed with

the current state of the collateral underlying each of the complex assets. In addition, expert investors would use statistical models to drive intricate cash flow models, which were, in turn, inputs into Monte Carlo valuation engines. Infrastructures like these can cost millions of dollars to build and millions more to maintain. Finally, for these models to have impact, large pools of capital are needed to take positions of great enough size to justify the substantial fixed investment in analytics. Without these expert investors, the price arbitrage process can quickly break down. Without arbitrage, prices will inevitably deviate from intrinsic value and liquidity will collapse as expert investors are forced to sell, while non-expert investors refuse to enter given the uncertainty in market pricing. The result is that prices must fall to "stupid cheap" levels in order to bring new buyers to the market who can participate without similar investments in analytics.[30] One indirect way to observe this is by looking at the kurtosis of complex assets relative to simple assets. The monthly mean, standard deviation and kurtosis of returns for several fixed income indices since 8/31/1999 are displayed in Table 3 below.

Table 3: Fixed Income Monthly Return Moments 8/31/1999–9/30/2009 (in %)[31]

Moment	US AGG	TSY	AGY	CORP	MBS	ABS	CMBS
Mean	0.52	0.51	0.51	0.54	0.53	0.44	0.52
Standard Deviation	1.09	1.42	1.08	1.81	0.84	1.27	3.08
Kurtosis Pre-Lehman	1.55	1.24	1.91	1.41	0.29	0.04	1.33
Kurtosis Full Sample	1.47	1.46	1.88	5.50	2.53	9.86	17.67

As can be seen from Table 3, kurtosis[32] in complex securitized assets such as commercial mortgage backed securities (CMBS) is over 12 times the kurtosis of simple assets such as US Treasuries, US Agency debt and even that of a broad fixed income index like the Barclays Capital US Aggregate. Furthermore, note that prior to the bankruptcy filing of Lehman Brothers, kurtosis in complex securitized assets was actually less than that of the Barclays Capital US Aggregate. However, when the liquidity crisis really hit after the Lehman bankruptcy, the kurtosis of complex securitized assets increased several fold while the kurtosis of simpler assets barely moved. In other words, the potential for prices in complex assets to gap substantially could not have been inferred from past data. Only the recognition that these markets were intrinsically more fragile, because only a few entities were truly experts in complex assets, would have alerted risk managers to the potential for large, negative tail returns.

As a result, all investors, and risk managers especially, need to use common sense and be cognizant of the complexity of the markets in which they operate. Risk managers should not view all new assets as Rubik's Cubes that necessarily have to be solved, nor should they fear being deemed unsophisticated if they find certain assets exceedingly complex. If smart risk managers cannot wrap their arms around a new idea after a reasonable amount of focused time, then it may be that very few people can as well. It is precisely these types of products that are susceptible to fragile market behavior. Complex markets will have fewer genuinely expert investors, and hence, any market dislocation can cause liquidity to quickly disappear. Risk managers must heighten their awareness of assets based on their complexity. For risk management purposes, complex assets should be grouped together with illiquid holdings when attempting to measure total portfolio exposure to liquidity risk. Complex assets must be assumed to always be illiquid, even while trading is robust and pricing is consistent with intrinsic value, since in a stressed scenario, these types of holdings are likely to be the first ones adversely affected.

2.1.4 Collateralization Can Be a Two-Edged Sword

The Credit Crisis has demonstrated that counterparty exposure is not just a theoretical risk. Many firms incurred large losses for the first time as Lehman Brothers failed and the immediate aftermath of the failure was handled in such a dysfunctional manner.[33] This financial catastrophe led market participants to attempt to better control their counterparty risk, including among other approaches, by aggressively extending their collateral agreements to cover situations where uncollateralized exposures remain. In general, collateralization can significantly reduce counterparty risk; but even with collateralization, many risks remain, though some more obvious than others.

First, institutions must still remain vigilant. For instance, they need to be alert to errors purportedly due to "computer problems" or "mistakes" and other signs of dealer stress when collateral transfers are due. Second, the collateral valuation process must be aggressively managed, and counterparties need to be ready to challenge dealers when appropriate, pushing back against opportunistic repo desks. While it is not uncommon for actual executable levels in the fixed income markets, particularly for less liquid securities, to be worse than the pricing from third-party pricing services, particularly during periods of market stress, the authors observed many situations during the Credit Crisis where repo desks used significantly more adverse prices than the prices provided directly from the trading desks of their own firms! Third, institutions need to carefully scrutinize the quality and value of collateral being delivered to them. The terms of collateral support agreements (CSAs) need to be read carefully to make sure that the type of collateral and haircuts are reasonable. Absent this detailed review, institutions may discover that for over-the-counter securities, the terms of trade do not protect borrowers sufficiently from being subject to forced liquidations at highly disadvantageous prices. Fourth, the CSAs need to be reviewed very carefully with respect to the process by which haircuts can be changed; at a minimum, notice periods should be required before any adverse changes in haircuts go into effect so that the borrower has time to either move their financing or to raise the necessary additional collateral. Lastly, institutions need to run stress tests on collateralized positions, particularly illiquid ones, which incorporate both extremely adverse market outcomes and adverse changes in the level of haircuts. Institutions that borrow against these positions must make sure that they have adequate liquidity to meet the contingent demands for liquidity.

A more subtle issue, though, is that institutions with limited liquidity must recognize that most collateral support agreements require two-way flows. Hence, while collateral support agreements reduce counterparty risk, they can also greatly increase (funding) liquidity risk for a (funding) liquidity-impaired institution. Changing market standards now often require cash or high-quality, liquid securities to meet collateral requirements. This means that collateral calls can easily force illiquid portfolios into a (funding) liquidity crisis even if there are no other external demands for cash, such as investor redemptions. In such a situation, the noble objective of trying to reduce credit exposure to counterparties could exacerbate (funding) liquidity risk. In cases where hedging is used to manage market risk, the same type of tradeoff may need to be made. However, while credit risk and market risk may prove to be very damaging, the inability to meet collateral calls can often prove to be fatal. The authors are aware of a number of liquidity impaired institutions that, when faced with this tradeoff, chose to either leave certain derivatives on a non-collateralized basis or to lift market hedges designed to reduce risk to avoid the likelihood of bankruptcy if they were presented with collateral calls because the inability to meet demands for collateral can set off rapid downward spirals in access to liquidity. Risk managers of institutions must be aware of this tradeoff and be prepared to balance normal risk management processes with the liquidity pressures that collateral agreements can create.

Perhaps the most famous downward "death" spiral of the Credit Crisis caused by collateral support agreements is the near collapse of AIG. Mollencamp et al. (2008) describes the counterparty risk associated with the credit risk models provided to AIG by a consultant, Gary Gorton.

> Mr. Gorton's models harnessed mounds of historical data to focus on the likelihood of default, and his work may indeed prove accurate on that front. But as AIG was aware, his models didn't attempt to measure the risk of future collateral calls or write-downs, which have devastated AIG's finances.
>
> The problem for AIG is that it didn't apply effective models for valuing the swaps and for collateral risk until the second half of 2007, long after the swaps were sold... The firm left itself exposed to potentially large collateral calls because it had agreed to insure so much debt without protecting itself adequately through hedging.

Table 4 below details the numerous collateral calls that eventually forced the US Treasury and Federal Reserve to commit $182 billion to prevent its collapse. It is very likely that AIG's insurance units were worth more than the losses incurred on CDS protection written by its Financial Products Group, AIGFP. However, the liquidity demands triggered by AIG's downgrades were so great that they quickly overwhelmed their ability to raise cash by selling assets. AIG's near collapse is an extreme example of the consequences of failing to account for the liquidity demands of collateral support agreements.

Table 4: AIG and the Two-Edged Sword of Collateral[34]

Date	Event	Collateral Posted	Cumulative Total
09/05/07	AIG posts $450m after GS demands $1.5b in collateral	$450m	$450m
11/01/07	AIG posts $1.5b after GS demands $3b in additional collateral	$1.5b	$1.95b
11/01/07–3/28/08	AIG discloses cumulative collateral posts of $5.3b	$3.35b	$5.3b
03/28/08–06/08/08	AIG discloses cumulative collateral posts of $9.7b	$4.4b	$9.7b
06/08/08–09/09/08	AIG discloses cumulative collateral posts of $16.5b	$6.8b	$16.5b
10/15/08	AIG forced to raise $14.5b in additional collateral after S&P downgrade	$14.5b	$31b
10/15/08–12/10/08	AIG discloses $37.3b in cumulative collateral posts and new government bailout of $150b	$6.3b	$37.3b

2.1.5 Liquidity Is a Common Risk Factor

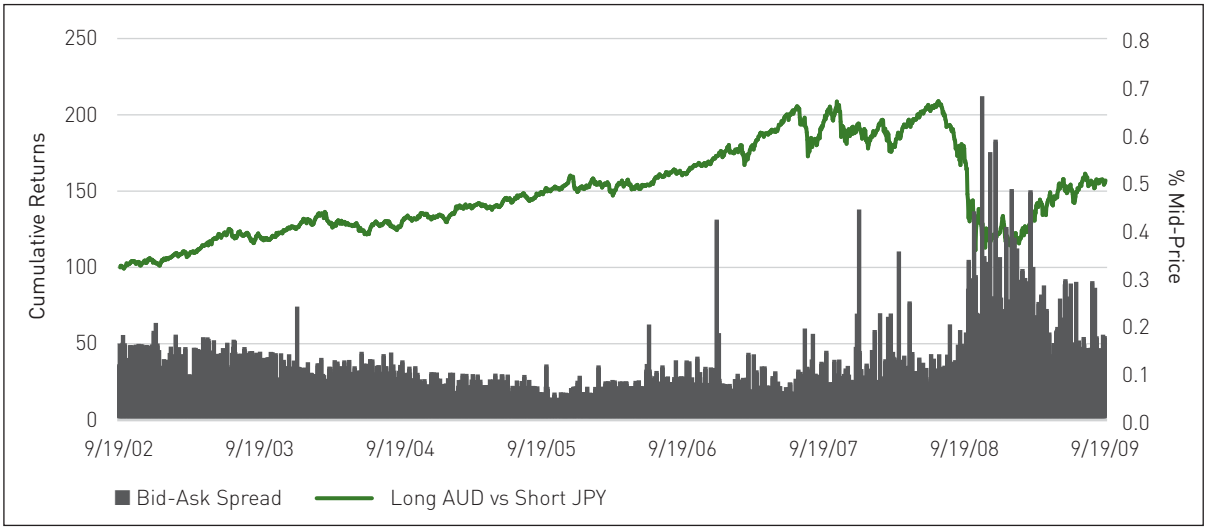
The (market) liquidity of an investment can have a material impact not only on the ability to raise cash by selling an asset but also on the level of market returns as well. Conceptually, it stands to reason that investors need to get paid a premium to hold illiquid positions since market liquidity represents a valuable option available to exercise. Pastor and Stambaugh (2003) and Amihud and Mendelson (1986) demonstrate that more illiquid securities have, in fact, earned higher rates of return over time. The existence of this premium creates a common risk factor, either directly or indirectly. The direct impact of (market) liquidity on asset returns is fairly well known. In periods where returns to liquidity are large, liquid and illiquid securities will show sharply negative correlations. For instance, in the fourth quarter of 2008 returns to liquidity were very high. The liquid Barclays Capital US Treasury Index had its highest quarterly return since the first quarter of 1986 at 8.75%, while the illiquid Barclays Capital Asset Backed Securities (ABS) Index and Barclays Capital CMBS Index had their lowest quarterly returns ever at -6.82% and -13.52%, respectively.[35]

However, the Credit Crisis has shown that risk managers need to monitor the liquidity risk on all their securities, even those that appear very liquid. Figure 1 below displays the cumulative returns of going long the Australian Dollar (AUD) and short the Japanese Yen (JPY) from September 2002 to June 2009. The long AUD, short JPY carry trade was an extremely popular position in the run-up to the Credit Crisis and according to any state-of-the-practice risk model, this trade should not have been exposed to liquidity risk. Foreign exchange markets are among the most liquid markets in the world, and both Japan and Australia are developed market economies making them relatively immune to the "sudden stops" in capital flows that can strike developing economies.

Despite what many risk models might indicate, however, this trade has very large exposures to liquidity risk. As a commodity exporter, Australian growth is much more exposed to illiquid, emerging market countries. Furthermore, this particular trade was extremely popular among market participants who used leverage to enhance returns. These market participants were also exposed to liquidity shocks, similar to those that afflict emerging market countries.

Market participants that exposed themselves to the liquidity risk of the long AUD, short JPY carry trade enjoyed several years of consistently strong returns. Between the fall of 2002 and summer of 2008, this position more than doubled in value. In less than a few months, however, nearly all those gains were wiped out in the fall of 2008. Liquidity shocks sent emerging markets economies and trade finance into a tail spin, putting pressure on commodity exporters such as Australia. Liquidity shocks also impaired funding to leveraged players just when trades such as the long AUD, short JPY carry trade were going against them. This forced many market participants to liquidate positions at exactly the same time. Hence, returns to the liquidity exposed carry trade became extremely negative and bid-ask spreads spiked over eight times.[36]

Figure 1: AUD/JPY Carry Trade Cummulative Returns and Bid-Ask Spread[37]



The above analysis demonstrates how even extremely liquid foreign exchange markets are exposed to the common risk factor of liquidity. It is interesting to note, however, that in a liquidity crisis more liquid securities can actually be hardest hit initially because liquidity-poor investors often have little choice but to sell their

most liquid positions first in order to minimize transaction costs. Liquid portfolios of all sorts became the "ATM machines" for many liquidity-strapped market participants. This common characteristic of various securities will, on occasion, create atypical correlations in the market where liquid positions all suffer declines together. As the liquidity crisis progresses, though, the adverse market impact on more illiquid securities appears to propagate more slowly. This is because the ability to measure changes in market values for these securities is more limited as the markets are themselves less transparent. However, declining liquidity will eventually lead to forced sales as lenders refuse to take illiquid securities as collateral for market value-based loans. In the later stages of a liquidity crisis, the value of illiquid securities will fall spasmodically with observed executions. At this stage in the crisis, liquid positions will significantly outperform as they retain more value relative to illiquid securities.

This is likely the exact phenomenon that generated the "Quant Crisis" that struck large-capitalization equity stocks in August 2007. Khandani and Lo (2008) find evidence the Quant Crisis resulted from the rapid unwind of equity portfolios with large exposures to the equity value risk factor or stocks with high earnings-, cash-flow- and book-value-to-price ratios. Furthermore, Litzenberger and Modest (2008; P.5) argue that the Quant Crisis started as "losses in the sub-prime credit market, extreme movements in credit spreads and the steep declines in prices of many buy-out related equities led to deleveraging by several large hedge funds and proprietary trading desks and ultimately to forced liquidations of positions held by many market-neutral quantitative equity strategies." As is well known, most equity value stocks quickly bounced back by the end of August 2007, and the liquidity crisis moved on to continue to devastate the securitized products from which the crisis originated. However, the Quant Crisis of August 2007 demonstrates the large losses that indirect exposures to the liquidity risk can generate even in extremely liquid positions such as large-cap equity. Quantitative equity funds desired to have exposure to the equity value risk factor due to its history of consistent, strong returns. Unfortunately, this pure play on equity value became a sizeable exposure to liquidity factor risk as this strategy became increasingly crowded by leveraged players.

The lesson worth remembering from the Credit Crisis is that liquidity is a common risk factor that can at times generate very large positive and negative returns. Risk managers need to carefully monitor positions with direct exposure to liquidity risk, such as securities with large bid-ask spreads, limited trading volume or high complexity as discussed in section 2.1.3. Risk managers must also monitor the indirect liquidity risk in their liquid positions. Unfortunately, indirect exposures to liquidity risk are difficult to measure quantitatively. However, crowded trades and embedded exposures to illiquid positions, such as bank stocks with their embedded exposure to complex, securitized assets, are warning signs that risk managers must closely monitor in addition to traditional quantitative measures of liquidity risk.

2.1.6 Portfolio Liquidity Risk Must Be Actively Managed

The Credit Crisis of 2007–2009 demonstrated that market risk itself cannot be effectively managed without serious attention first being paid to managing (market and funding) liquidity risk. Depending on the characteristics of the liability being funded by a portfolio, the portfolio may experience expected and unexpected demands for liquidity. These demands need to be anticipated when managing the portfolio. Anticipated liquidity demands need to be matched with the portfolio's ability to supply the liquidity. Determining a portfolio's ability to supply liquidity requires decomposing it position by position. Figure 2 below demonstrates one method for achieving this decomposition. By looking at the entire distribution of portfolio liquidity, risk managers can get a sense of how much cash can be raised and over what period of time. Simply averaging the liquidity

across positions is not sufficient since many portfolios may have a barbelled liquidity structure. There are, of course, many valid critiques to such a simple approach. The main objection is that liquidity is exceedingly difficult to forecast, and in times of distress, "average" market liquidity behavior is unlikely to be relevant. Nevertheless, our experience is that even relatively simple metrics help highlight the general picture of a portfolio's liquidity distribution and, as such, are quantitatively useful. The pre-crisis structure of risk management functions did not necessarily focus on these types of issues. Hence, even connecting organizational data flows, so that subscriptions and redemptions become a normal part of the risk surveillance process, is value added.

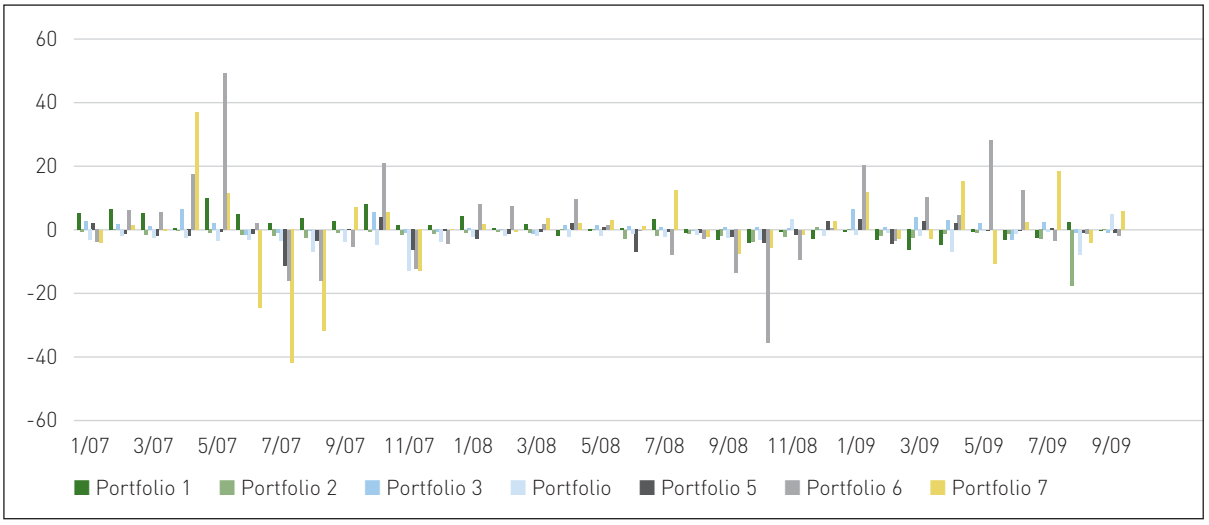
Figure 2: Portfolio Liquidity Supply[38]

Current Liquidity Data as % of NAV: Days of 3-Month Average Daily Volume Owned (Gross Exposure + Cash as % of NAV)

Fund/ Sector	Base NAV ($m)	Cash	<0.2 Day	0.2-1 Days	1-3 Days	3-5 Days	5-10 Days	10-20 Days	>20 Days	Private Plcmt	Volume NA	Total (ex. cash)
Team ABC	1,718	26.1	11.0	15.4	11.7	6.9	11.4	7.5	9.9	0.0	0.1	73.9
Strategy 1	243	6.9	4.9	20.3	22.5	9.7	13.4	10.4	11.6	0.0	0.3	93.1
Portfolio	25	4.5	20.5	34.2	23.2	7.2	3.9	4.7	1.7	0.0	0.0	95.5
Portfolio	79	6.6	5.2	25.7	20.9	10.8	10.9	8.2	11.3	0.0	0.4	93.4
Portfolio	130	1.9	2.1	15.8	25.0	10.1	17.6	13.5	13.7	0.0	0.3	98.1
Portfolio	9	85.4	0.0	0.0	0.0	0.8	2.8	0.0	10.9	0.0	0.1	14.6
Strategy 2	61	6.1	19.9	41.5	16.9	7.7	3.1	1.6	2.7	0.2	0.2	93.9
Portfolio	37	4.7	16.8	42.5	19.8	8.9	2.9	1.2	2.8	0.4	0.1	95.3
Portfolio	25	8.2	24.5	40.1	12.5	5.9	3.5	2.3	2.7	0.0	0.4	91.9
Strategy 3	158	8.5	9.3	34.4	21.0	8.6	8.5	4.2	5.4	0.1	0.1	91.5
Portfolio	44	8.7	12.6	33.8	21.5	7.3	7.5	3.2	5.5	0.0	0.1	91.3
Portfolio	57	8.3	8.0	34.6	20.7	9.3	8.8	4.2	6.1	0.0	0.1	91.7
Portfolio	57	8.6	8.0	34.6	21.0	9.0	9.0	4.9	4.6	0.4	0.1	91.4
Strategy 4	814	2.2	18.0	15.9	11.9	8.8	17.1	10.7	15.3	0.0	0.0	97.8
Portfolio	6	4.9	46.5	27.9	16.4	1.3	0.2	2.5	0.3	0.0	0.0	95.2
Portfolio	11	3.6	32.6	40.6	12.5	6.5	1.3	0.6	2.4	0.0	0.0	96.4
Portfolio	37	0.3	23.3	6.3	21.5	31.4	17.3	0.0	0.0	0.0	0.0	99.8
Portfolio	199	1.0	0.0	3.1	23.6	17.2	15.0	16.4	23.7	0.0	0.0	99.0
Portfolio	515	2.3	21.5	19.9	6.6	4.3	19.9	10.5	14.9	0.0	0.0	97.7
Portfolio	50	5.2	47.2	27.2	12.1	6.5	1.9	0.0	0.0	0.0	0.0	94.8
Portfolio	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strategy 5	8	19.9	37.5	30.4	12.2	0.0	0.0	0.0	0.0	0.0	0.0	80.1
Portfolio	7	11.8	41.2	33.5	13.4	0.0	0.0	0.0	0.0	0.0	0.0	88.2
Portfolio	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strategy 6	433	91.1	0.2	0.7	1.2	1.0	2.0	2.1	1.8	0.0	0.0	8.9
Portfolio	395	90.2	0.2	0.8	1.3	1.0	2.2	2.3	1.9	0.0	0.0	9.8
Portfolio	38	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 3 below displays the liquidity demand profile of a number of illustrative portfolios. Negative spikes represent portfolio outflows while positive spikes represent inflows. Tracking the history of liquidity demands enables institutions to attempt to anticipate demands for liquidity in the future. As discussed previously, this is a very simplistic approach that may not be predictive of liquidity demands in a crisis. However, our experience is that it is quite constructive to force risk takers to explicitly focus on the liquidity demands facing their portfolios. These demands for liquidity can then be compared to the portfolio's ability to supply liquidity as detailed in Figure 2. This enables risk managers to qualitatively assess whether forecasted demands for liquidity can be met. Moreover, the report also allows you to see how the liquidity profile of the portfolio would change given an outflow. One particularly difficult challenge can arise in managing redemptions from pooled vehicles. While it is common to make sure that valuations are equitable, managing the changing level of liquidity in an equitable fashion for a pooled vehicle facing redemptions is quite challenging. The Credit Crisis has shown that similar reports and analytics must be developed so that portfolio liquidity can be measured with the same level of detail as other more traditional portfolio management functions. While this is certainly an area requiring additional academic research, institutions should not let the absence of a developed literature and established techniques prevent them from taking action. Instead, risk managers should immediately begin to track portfolio liquidity supply and demand and introduce more sophisticated analytics as their expertise and new research in the field advances.

Figure 3: Portfolio Liquidity Demand (% of Portfolio NAV)[39]



2.2 Investors in Securitized Products Need to Look Past the Data to the Underlying Behavior of the Assets

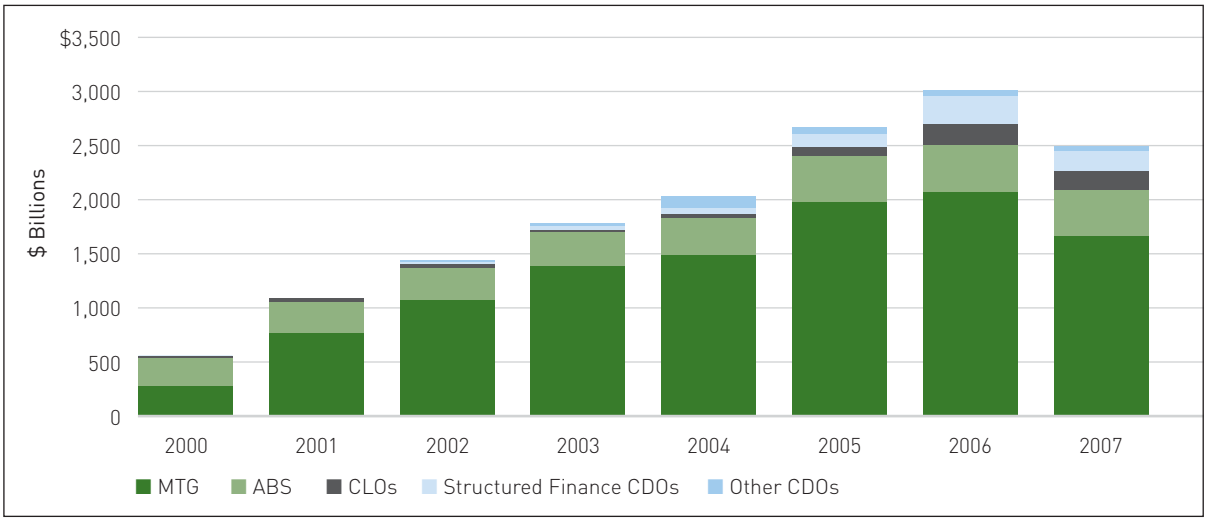
As is generally well accepted, the genesis of the Credit Crisis was in complex and, in retrospect, poorly understood securitized US mortgage products.[40] Many market participants were subsequently caught off guard by their inability to substantively assess the underlying exposures in those products. One lesson certainly worth remembering from the Credit Crisis is broadly applicable to avoid future dislocations. Investors and risk managers need to be more hands-on and develop a deeper and more direct understanding of the underlying assets, including the behavior, incentives and current practices of the borrowers, servicers and the origination process. Furthermore, this hands-on knowledge needs to be adequately incorporated into risk analytics and models. The original attraction of securitization was that it provided ways for investors to easily and efficiently invest in new asset

classes and obtain portfolio diversification through ownership of different types of market "beta." Ideally, securitization permits information costs to be greatly economized. Securitization should in theory lead to the standardization of investment vehicles and enhanced liquidity for the underlying assets being securitized.

Many distinct players are involved in the securitization process. Originators make loans to individual borrowers for varied needs, be it residential mortgages, credit cards, car purchases or commercial real estate. In some cases, the originators sell all their loans immediately or act solely as agents for portfolio lenders. In other cases, they might warehouse loans prior to selling them for securitization. Investment bankers assemble deals by bundling together pools of the underlying assets and then make available to investors the initial data on pool characteristics. Rating agencies initially assess the credit risk of deals, rate them and then continue to monitor risks throughout the life of the product. Servicers then provide ongoing information on the underlying pool of assets' performance. Finally, broker/dealer trading desks make markets in the different tranches of the securities, as well as provide investors with the regular market valuations they require. They also stand by willing to commit their capital to provide investors with (market) liquidity by making reasonably tight secondary markets.

The net result of these endeavors was to increase investor access to new asset classes and drive rapid growth in the issuance of securitized assets in the run-up to the Credit Crisis as displayed in Figure 4 below. After years of relative success, combined with the development of increasingly sophisticated analytical and statistical modeling, these efforts also began to encourage a sophisticated style of "analytically-intensive armchair risk management" that relied on data, statistical models and technology to perform surveillance over portfolios versus "boots on the ground." The Credit Crisis has demonstrated the limitations of this investment process as many securitized products were racked by severe defaults, delinquencies and loss severities completely outside the realm of expectations. The quality and performance of underlying assets turned out to be materially worse than expected. The integrity of the actual underwriting standards and borrower behavior are now known to have been much worse than what many investors ever anticipated. These revelations, however, were probably not as big a surprise to many loan brokers, originators and servicers. In many cases, behavior by borrowers and lenders were borderline fraudulent, and this was not something that any amount of data analysis or modeling could ever uncover.[41]

Figure 4: Growth in Issuance of Securitized Assets[42]



Therefore, a key lesson of this crisis is that investors seeking to participate in these products need to get involved more deeply in the information cycle. A method for assessing the quality, completeness and relevance of data must be developed. In many cases, there will be no substitute for direct due diligence by investors. In the run-up to the Credit Crisis, for instance, data showing low default and delinquency rates masked deteriorating borrower and collateral quality as home equity cash-outs increased aggregate leverage in the household sector. Collecting and analyzing more default and delinquency data alone would never have revealed the significant slide in lending standards. The standard data on securitized products had lost its information content. Only field level research and the collection of additional non-standard data on the underlying assets would have alerted investors to growing problems. A perfect example of this is the Countrywide Home Loan Mortgage Pass-Through Trust 2007-HY7 (CWHL 2007-HY7) detailed in Table 5 below.[43]

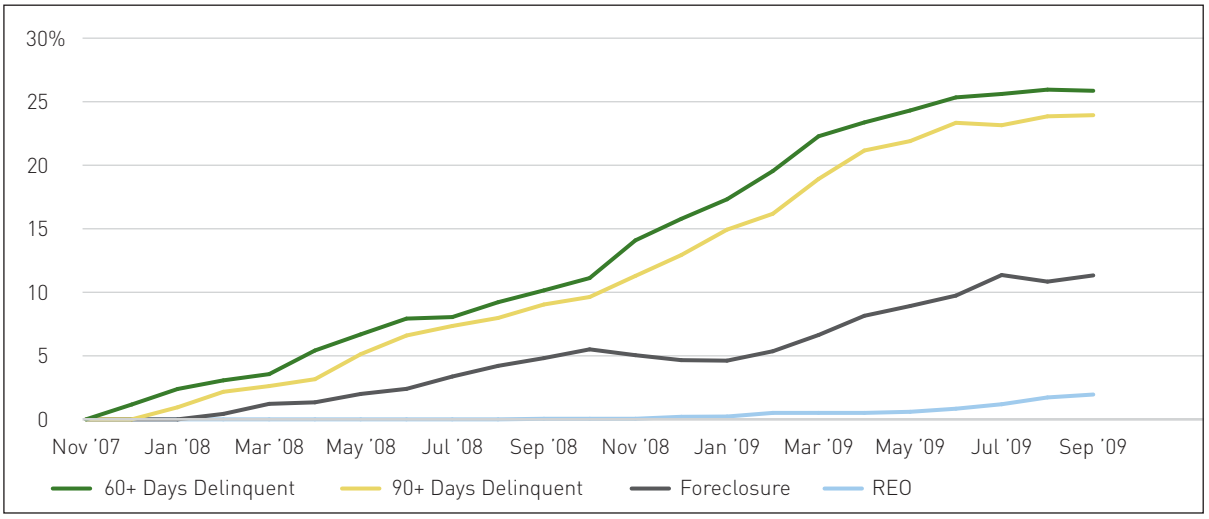
Table 5: CWHL 2007-HY7 Pool and Loan Group Characteristics[44]

	Loan Group 1	Loan Group 2	Loan Group 3	Loan Group 4	Total Pool
Principal Balance	$63,330,778	$219,914,897	$177,522,952	$99,209,739	$559,978,366
Principal Balance (%)	11.31	39.27	31.70	17.72	100.00
Fixed-Rate Period (months)	36	60	84	120	75.52
CA Mtg Loans (%)	36.56	43.65	40.47	65.55	45.72
Loan to Value (%)	72.44	70.85	71.30	72.40	71.45
Avg Current Mtg Rate (%)	6.09	6.62	6.66	6.77	6.60
Avg FICO Score	738.00	735.00	743.00	739.00	738.58

As can be seen from Table 5, this particular non-agency residential mortgage backed security had collateral characteristics that appear very favorable. The mortgage loans are to prime borrowers with a weighted average FICO score of 738.58.[45] These mortgages are first lien loans, and borrowers are well above water with a weighted average loan to value (LTV) of less than 72%. CWHL 2007-HY7 consists of conventional hybrid adjustable-rate mortgages, and the weighted average fixed-rate period is over six years. CWHL 2007-HY7 does have a high percentage of California loans at 45.72%; however, California had been one of the strongest housing markets for many years. CWHL 2007-HY7 was securitized into 34 certificates, 27 of which were offered and seven certificates that were not offered. Both Moody's and S&P rated 24 of the 27 offered certificates AAA. The remaining three certificates were rated Aa2, A2 and Baa2 by Moody's and AA+, AA and A by S&P. Hence, all of the offered certificates were rated at least investment grade by Moody's and S&P.

Figure 5 below shows the actual credit performance of CWHL 2007-HY7 since its issuance in late 2007. As can be seen from the delinquency and foreclosure rates, this deal has been a total disaster. With only 20 months having passed since issuance, over one-quarter of the pool is 60 days delinquent and nearly 10% of the pool is in foreclosure. Investors and ratings agencies thought that CWHL 2007-HY7 was a high-quality deal with prime borrowers, a 739 FICO and 72% LTV. Unfortunately, these statistics had lost their information content as the housing bubble progressed and the nature of the collateral changed.

Figure 5: CWHL 2007-HY7 Collateral Performance[46]



As the housing bubble progressed more borrowers sought loans with more favorable repayment terms, added leverage and relaxed underwriting standards, including higher quality prime borrowers. In order to meet these demands by borrowers, and satisfy strong investor demands for mortgage backed securities with high FICO scores and low LTVs, originators began to issue a very different kind of mortgage. These new mortgages included the increased use of interest-only features, higher combined LTVs through the use of second lien mortgages and home equity loans, and relaxed underwriting standards, such as increased issuance of less-than-full documentation loans. Returning to our CWHL 2007-HY7 deal, had you actually known what characteristics to look for, obtaining additional information from the loan prospectus would have revealed that CWHL 2007-HY7 contained riskier mortgages than even the contemporary pools of prime mortgages. For example, as shown in Table 6 below, 95% of the loans are not fully amortizing compared with 84% of the 2007 prime cohort and 80% of the borrowers did not fully document their income compared with 63% of typical 2007 prime mortgages. However, the change in the mortgage origination market was so pronounced that even these additional statistics do not fully capture the slide in lending standards. For instance, Missal and Richman (2008) note that some at subprime lender New Century "measured loan quality by whether the loan could be sold, not whether it was likely that the borrower would meet his or her obligation," and the Federal Bureau of Investigation (2008) states that 63,713 mortgage fraud reports with possible losses of over $1.4 billion were filed in fiscal year 2008. In light of this information, it is not surprising to that one-quarter of the CWHL 2007-HY7 pool is seriously delinquent compared with "only" 8% of similar vintage loans. The seismic shift in collateral risk over time made it difficult for models relying on previously sufficient summary statistics to accurately capture the dramatic rise in delinquencies and defaults that would later be realized.

Table 6: Deteriorating Quality of Underlying Assets[47]

	CWHL 2007-HY7	2007 Prime Hybrid Cohort
Combined LTV (%)	77	74
Less-than-Full Documentation (%)	80	63
Interest Only (%)	95	84
60+ Days Delinquent (% of Current Balance)	25	8

Borrowers and originators knew the collateral characteristics that investors and ratings agencies demanded, and they worked hard to supply that demand. Unfortunately, investors and ratings agencies were not intimately involved in the underlying origination process. They could not look through the securitized products they were investing in and rating to see the other flaws in the collateral beyond the standard summary statistics they had come to depend on. As a result, when collateral statistics such as FICO and LTV failed to predict collateral performance, market participants were continually surprised to the downside as collateral performance well exceeded potential loss estimates provided by armchair risk management.

Another way to think about this problem is through the paradigm of managing model risk. Traditionally, this has been thought of as a highly quantitative process to determine if the mathematics and computational implementation of a model is robust and correct. However, there is another dimension of model risk, which is the risk that while the computations in the model may be correct, the phenomena being modeled may be incomplete or even irrelevant. From this perspective, the "risk" that needs to be managed is that the analytical model or statistical characterization of risk may simply be missing the relevant and ever-changing nature of the actual behavior of the underlying assets. Therefore, if an institution has investments in securitized assets, then not only must it acquire the analytical capability to understand the risks of its investments, but it must also invest in a process to make sure that the models it is relying on remain relevant to what is happening with the underlying assets.

Statistically, failing models can be identified by observing their mistakes. However, a much less expensive way to identify failing models is to maintain a better understanding of the underlying behavior of the assets. This latter task does not necessarily lend itself to the degree of (false) analytical precision as many quantitatively oriented finance practitioners might like, but the Credit Crisis has demonstrated that it is folly to assume that highly dispersed economic phenomena can always be managed by a misguided faith in the law of large numbers. As is the nature of every economic system, if the system knows that large entities are relying on a particular type of model, other participants in the system will adapt their behavior opportunistically from the perspective of those models. It certainly could be argued that investors in AAA-rated tranches thought that their investments were sufficiently "out-of-the-money" to any reasonable estimate of model risk so that this level of expertise was not required. However, billions of dollars lost has taught us that this assumption was wrong. Risk managers must either make sure that their institutions are managing their model risk or choosing not to participate in these markets.

2.3 Certification Is Useless During Systemic Events

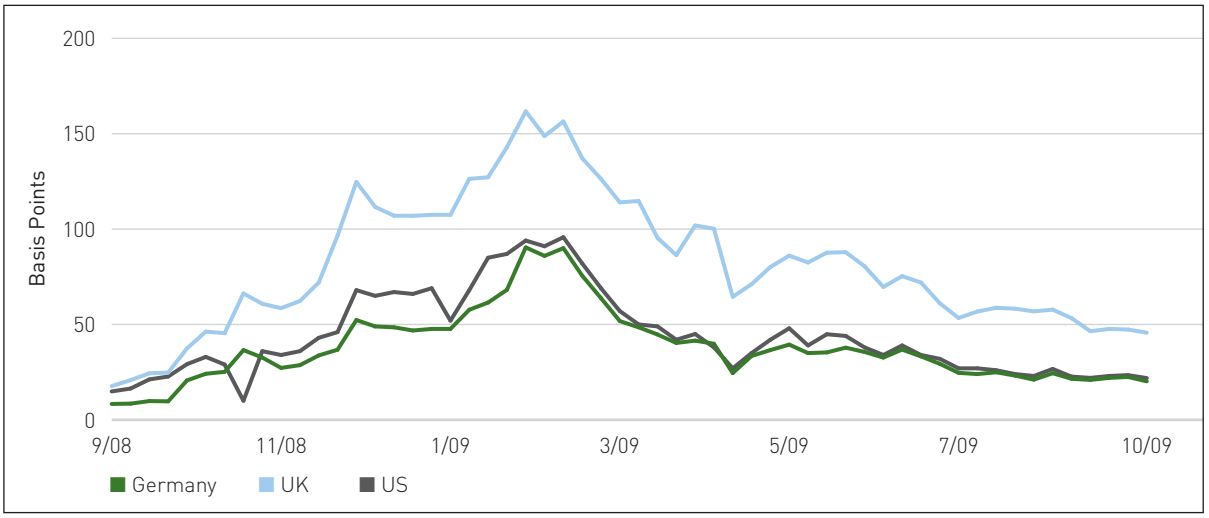
The recent crisis has revealed the fallacy of relying upon thinly capitalized "certifiers" of financial products. Bond insurers, auction managers, Fannie Mae, Freddie Mac and even the value-added provided by rating agencies have all been substantially washed away by the Credit Crisis. While investors can and should access third-party information providers, prudent investors need to rely more upon their own credit analysis and surveillance capabilities to understand the underlying credits that are ostensibly being "wrapped" by other institutions. If funds are not willing or able to do this, then they should probably choose not to invest in those particular classes of assets.

Table 7: Pre-Credit Crisis AAA Ratings by Security Type[48]

Entity	Number of AAA Ratings	AAA Ratings as Percent of Total
Structured Finance	37,000	60
Insured Municipal Bonds	22,324	47
Non-Insured Municipal Bonds	2,292	5
Sovereign Nations	19	17
US Corporations	9	<1

Risk managers also need to be extremely skeptical of any form of insurance against systemic risks. Table 7 above details how many structured products and insured municipal bonds were rated AAA by ratings agencies prior to the Credit Crisis. In 2006, only nine US corporations received the top rating, however, over 37,000 structured finance deals and 22,324 insured municipal bonds were rated AAA. The amazing proliferation of AAA ratings and the little attention that such proliferation received at the time demonstrates how reliant market participants had become on certifiers to protect them from systemic risks.

Figure 6: Sovereign Credit Default Swap Spreads[49]



Ironically, the overreliance on certifiers by market participants was so pervasive that it became a systemic risk in its own right. The situation got so bad that much of the market had become totally dependent upon the government to provide direct guarantees and recapitalizations that market participants had previously believed would be provided by certifiers. Most notable among these were the various capital injections and debt guarantees extended to banks by governments around the world after AAA-rated securities began to default and bond insurers failed to protect the principal guaranteed in insurance contracts.[50] Of course, what remains to be seen is the robustness of the government's guarantees. If those guarantees fail, then it is hard to imagine that other elements of the financial system will survive, except direct holdings of precious metals. However, as can be seen in Figure 6 above, fears about these government guarantees have clearly abated since March 2009.

A key lesson from the Credit Crisis worth remembering is that systemic risks are systemic, and risk managers must be extremely skeptical of any entity that attempts to protect their institutions from such risks. Risk managers must closely monitor and control the absolute size of all systemic risk exposures excluding certifier protections. Assuming that certifier protections will shield institutions from systemic risk exposures can have catastrophic results when those risks are realized.

2.4 The Market's Appetite for Risk Can Change Dramatically

The run-up to the Credit Crisis saw compression in almost all measures of risk premia. The collapse of the term premium caused former Federal Reserve Chairman Alan Greenspan to make his famous bond market conundrum comments in February 2005, and the search for yield caused real estate cap rates, credit spreads and liquidity premiums to fall to record lows.[51] Volatility also declined and many market observers remarked that economies and financial markets had become more flexible and diversified, and hence, more resilient to unexpected shocks. As is well known, however, these developments were dramatically reversed as various measures of risk premia abruptly rose from record lows to highs.

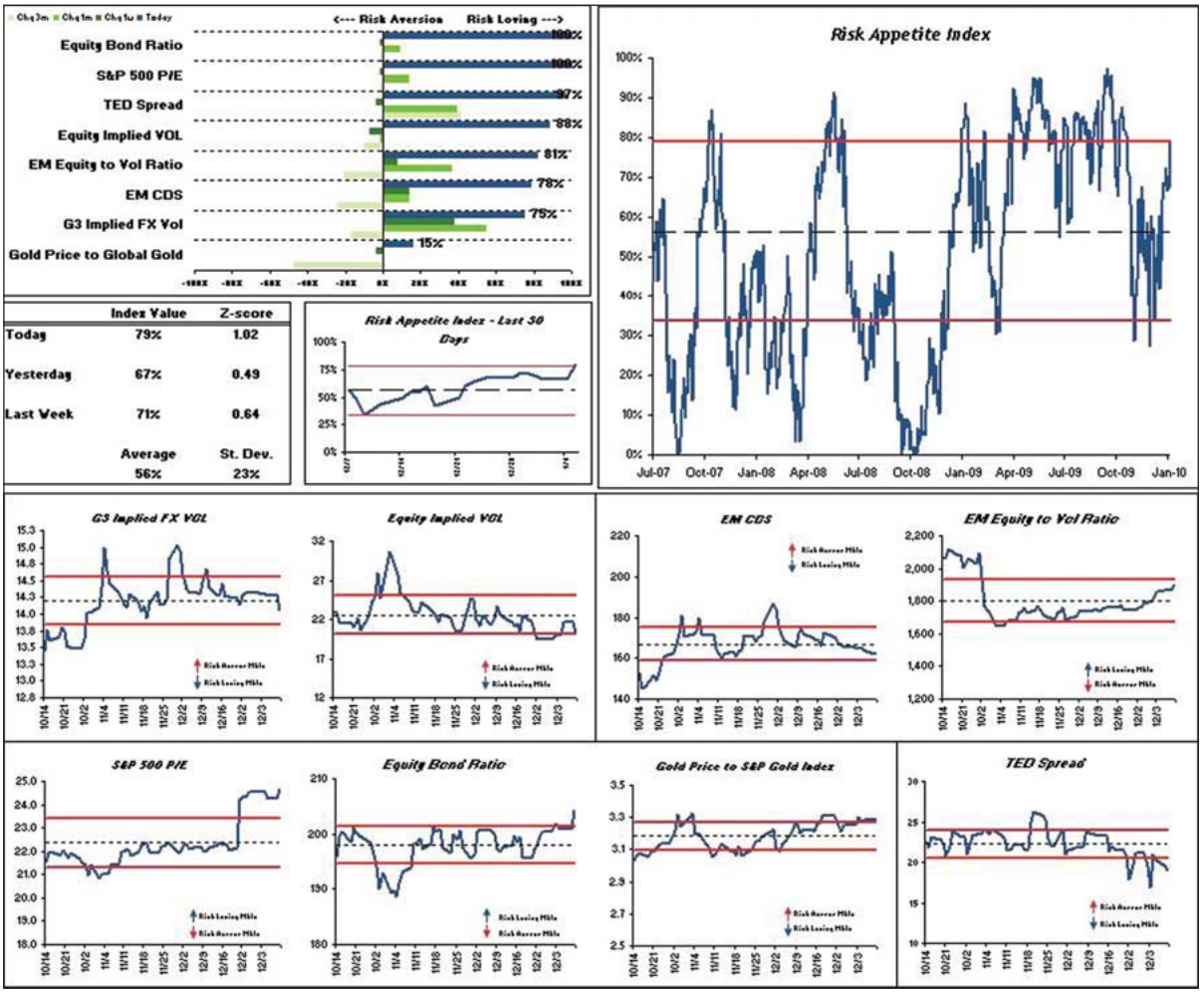
The fact that market risk appetite can swing up and down over short periods of time has been documented before. For instance, Shiller (1981) shows that stock price volatility is as much as 13 times greater than the volatility of real dividends. However, even though it is well known that risk appetite is volatile, it is still easy for risk takers to overestimate the persistence of risk appetite regimes. A lesson from the Credit Crisis worth remembering is that risk managers must be very vigilant about investments that require continuity in risk appetite or in the ability to foresee risk appetite changes.

Table 8: Risk Appetitie Index Components[52]

Risk Factor	Description	Risk Loving	Risk Averse	Interpretation
Market Volatility (Vol)				
G3 Implied Vol	Implied Volatility from EUR, GBP and JPY	▼	▲	Uncertainty in the FX market
Equity Implied Vol	S&P Volatility Index-VIX	▼	▲	Uncertainty in the equity market
Emerging Markets (EM) Risk				
EM CDS	Emerging Markets Spreads: Brazil, Russia and Turkey 5-year CDS Contract	▼	▲	Credit risk in 'high beta' emerging markets
EM Equity to Vol Ratio	Brazil, Mexico, Turkey, India Stock Exchange Indices: Index level divided by realized volatility	▲	▼	Sovereign risk in volatile emerging markets
Risk Appetite Ratios				
S&P 500 P/E	S&P Adjusted Price Earning Ratio	▲	▼	Confidence in corporate profits growth
Equity Bond Ratio	FTSE World Index over Treasury, Bund and JGB bond prices	▲	▼	Flight to quality, movement in global equities vs. government bonds
Gold Price to Global Gold	Gold Spot Price over S&P Gold Index	▼	▲	Gold as 'safe haven' manifests when gold equity sector does not follow gold spot
Market Liquidity				
TED Spread	3-month Libor–3-month Treasury rate	▼	▲	Liquidity risk

Risk managers should develop tools to help track changes in risk appetite. Table 8 above details the construction of a market risk appetite index.[53] The goal of the risk appetite index is to aggregate factors that are reliable measures of global market risk. As discussed in Park, McCormick and Jiltsov (2007), the factors used to create the aggregate risk appetite index need to have three characteristics: (i) direction of factor movement needs to be consistent with economic intuition; (ii) factors need to show significant responsiveness to changes in market risk; and (iii) factor changes should have low cross sectional correlation. The arrows in Table 8 indicate which direction the factor moves when markets become more risk loving or risk averse.

Figure 7: Short-Term Risk Appetite Index 3-Month Time Horizon[54]

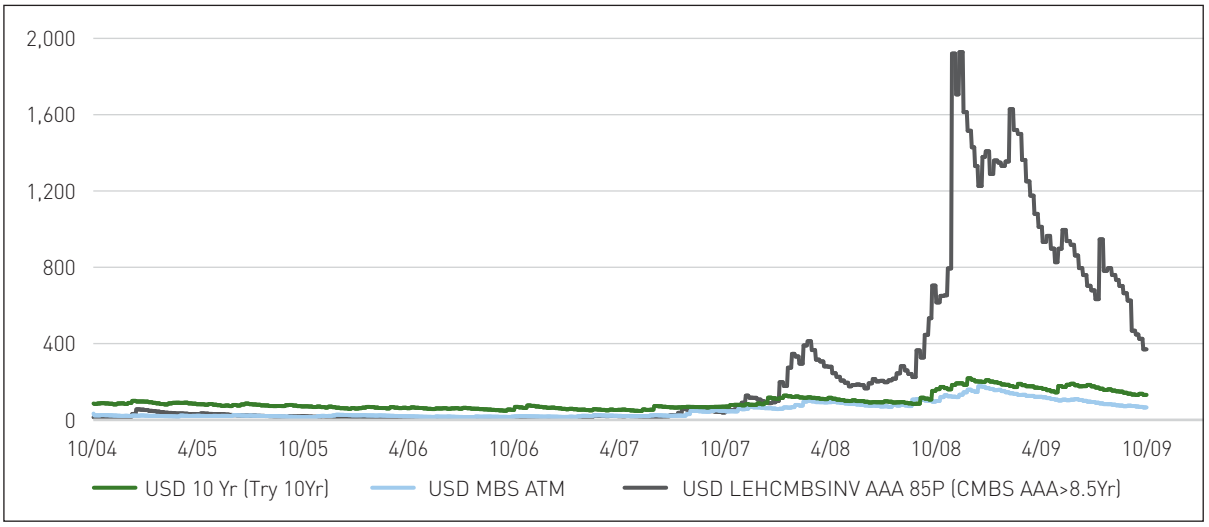


Each risk factor detailed in Table 8 is given a percentile rank for the sample period. Rankings are sorted in order to make high percentiles indicative of high risk appetite markets and low percentiles indicative of low risk appetite markets. Percentiles are then simply averaged together to determine the overall level of the market risk appetite index for a particular time frame. An example of the BlackRock Short-Term Risk Appetite Index for a three-month horizon is displayed in Figure 7 above. The short-term risk appetite index is meant to capture high-frequency changes in risk appetite. Extending the risk appetite time horizon to one year or more can help capture long-term changes in market risk appetite. The aggregate risk appetite index is displayed in the upper-right panel of Figure 7, and the index components are displayed in the lower panel of Figure 7. The upper-left panel of Figure 7 displays the change in index components over three months, one month, one week and one day, as well as diagnostics on the aggregate risk appetite index.

2.5 The Market's Level of Risk Can Change Dramatically

Along with large changes in risk appetite, the market's level of risk, as measured by volatility, can also change dramatically. Asset and risk factor volatilities that previously had been low can quickly spike up. Moreover, correlations also tend to increase when market risk rises. As a result, portfolio risk can increase even faster than individual market risks as diversification falls. Figure 8 below demonstrates just how quickly market volatilities can change. It shows the annualized volatility of 10-year spot US Treasury rates, at-the-money US Agency mortgage spreads and commercial mortgage backed security spreads as measured by the Barclays Capital AAA CMBS 8.5+ year weighted-average-life index for the five-year period from July 2004 until October 2009. As illustrated, the increase in CMBS spread volatility is truly staggering, rising over 1,200 basis points.

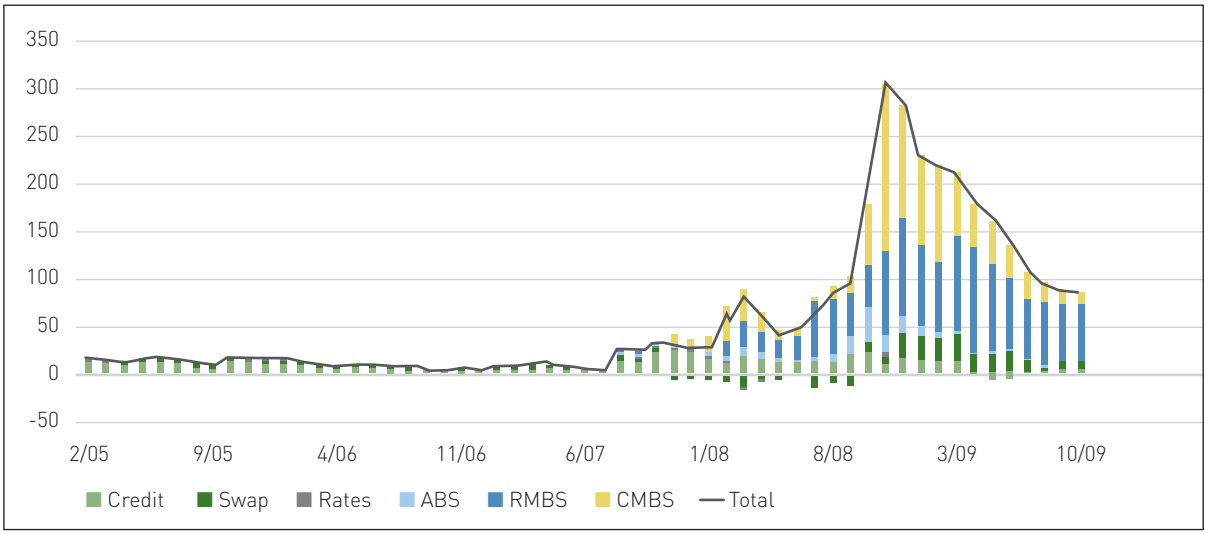
Figure 8: Annualized Volatility July 2004–October 2009 (in Basis Points)[55]



In addition to changes in the market's level of risk, the composition of risk can also radically change. Certain assets and risk factors that at one time displayed low volatilities can become highly volatile when crises erupt. Historically volatile assets are often closely watched by investors and risk managers since their ability to create large losses and gains is well documented. Risk management techniques and resources are often devoted to track and manage these known volatilities. As Figure 9 demonstrates below, however, formerly low volatility assets can quickly become major sources of risk.

The graph below displays the risk decomposition of a fixed income portfolio actively managed against the Barclays Capital US Aggregate Index whose active risk factor exposures were held constant for the last five years. Before the Credit Crisis of 2007–2009, interest rate and corporate credit risk were clearly the largest contributors to active risk. Once the Credit Crisis begins, however, the level of risk increases sharply and the composition of risk changes dramatically. Exposures to securitized assets suddenly become the dominant sources of risk whereas previously they contributed very little risk. Risk managers must be prepared for the changing level and composition of market risk.

Figure 9: Active Risk for Constant Exposure Portfolio July 2004–October 2009 (in Annualized Basis Points)[56]



2.6 Don't Let the Market Determine Your Level of Risk

Risk management, in its most literal form, is about managing the risk of a portfolio, which means not only constraining the active decisions of portfolio managers, but also preventing the level of portfolio risk from being carried away by the market outside of acceptable boundaries. While markets have recovered much of their losses as of the writing of this paper, financial history has clearly demonstrated, time after time, that it is not always possible to hold desired long-term positions through all market conditions. As Keynes famously said, "the market can stay irrational longer than you can stay solvent" (quoted in Finkelstein 2006). Risk managers not only need to have cutting-edge knowledge of the latest models and techniques, but also a historical perspective on how bad financial crises can actually get.

As discussed, the level and composition of market risk can quickly change and active decisions need to be made about how to respond to changes in market risk. Note that a portfolio manager's ability to manage down the increased level of risk may be constrained as many relevant trading markets shut down. Unfortunately, managing the level of risk may result in being a seller at precisely the "wrong" time. The risk of being "whipsawed" by V-shaped recoveries in financial markets is real and can negatively impact returns. Best practices will constrain levels of risk proactively based on predetermined risk tolerances. This way, the risk of being whipsawed is more limited. Moreover, doing nothing means that risk levels will be determined by the market, and ultimately, the level of risk needs to be consistent with the institution's fiduciary responsibilities.

The worst situation, but unfortunately all too common, is for institutions to get "risk management religion" right after a dose of excessive risk. Once the horse is out of the barn, the risk of being whipsawed is the greatest. However, even in such challenging situations, the ultimate arbiter of the appropriate level of risk is the institution's ability to bear risk. Institutions with large, near-term liquidity demands may not be in a position to try to ride out the storm, whereas an institution with a stable base of funding and capital can much better afford to see if the market reverts to more stable, long-run valuations. Market fluctuations do not respect the risk tolerances of individual institutions, and only active risk management can protect them from undesired levels of risk as market volatilities change.

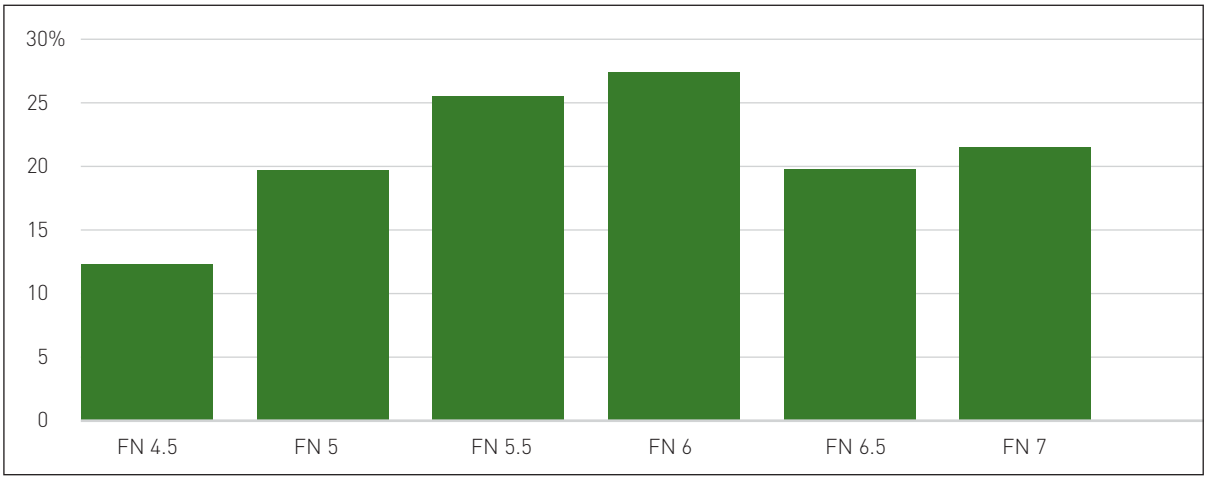
2.7 The Changing Nature of Market Risk

Across the globe, power and control over the financial system is shifting from financial to political capitals. The scale of intervention by governments around the world is truly without precedent. Tables A.1 and A.2 in the Appendix detail at least 99 interventions into private markets made by governments in the US and around the world. The number and scale of these interventions leave little doubt that government will be a major player in the workings of the market for some time to come.

As a result, policy changes are becoming major drivers of market dynamics. In many markets, policy risk has surpassed economic fundamentals and market technicals as the primary source of risk. In some ways, markets in the developed world are behaving in ways that are consistent with the policy risk typically assumed to exist in emerging markets. The risk management teams of the future may come to rely somewhat less on economists and statisticians and lean more on politically oriented analysts. Standard quantitative techniques are not well equipped to deal effectively with policy risk. This is because changes in policy often result in a structural break in the covariance of economic variables.

For example, consider Figure 10 below, which shows the average monthly conditional prepayment rate (CPR) for 30-year Fannie Mae mortgage backed securities (MBS) by coupon, from January 2009 to September 2009. Despite having larger incentives to refinance, 6.5 and 7 coupon MBS are actually prepaying at a slower rate than 6 and 5.5 coupon MBS. There is, of course, an obvious economic reason for this relationship. Borrowers in high-coupon mortgages tend to have higher LTVs and lower FICO scores than borrowers in low coupon mortgages, and due to the stress in the banking system, mortgage lenders are currently reluctant to refinance low credit quality borrowers. However, this dynamic could very easily change if legislation was passed to make it easier for low credit quality borrowers to refinance. If such a policy change were to occur, then the prepayment risk in higher coupon MBS would instantly increase. This spike in prepayment risk would represent an obvious structural break in the economic relationship between prepayments and borrower credit quality that no econometric model of prepayments could be expected to forecast.

Figure 10: Average Monthly CPR January 2009–September 2009[57]



Moreover, the above analysis is extremely relevant to today's market environment given that the federal government has already passed legislation such as the Housing and Economic Recovery Act which in part aims to reduce foreclosures by making refinancing into Federal Housing Administration loans easier.[58] Currently the program would cover at most 400,000 borrowers, but if the program was expanded, the bar graph in Figure 10 could change dramatically. In such an environment, the qualitative analysis of savvy political analysts may result in a better read of the factors most likely to drive markets than traditional risk managers.

Cho et al. (2009) reports on the beginning of this transition, as a number of financial institutions are speaking openly about the growing importance of getting better plugged into the political process.

> As financial firms navigate a life more closely connected to government aid and oversight than ever before, they increasingly turn to Washington, closing a chasm that was previously far greater than the 228 miles separating the nation's political and financial capitals... In response, senior executives of major financial companies are traversing the Beltway to meet lawmakers in person for the first time. Firms such as Fidelity Investments, BNY Mellon and even Goldman Sachs, which has prospered in the crisis relative to many other banks, are opening additional offices or bulking up their staffs in the capital.

Risk management organizations will also need to invest in acquiring the human capital that can provide the qualitative analysis demanded by the heightened importance of policy risk.

2.8 By the Time a Crisis Strikes, It Is Too Late to Start Preparing

An effective and robust risk management process requires a material and sustained commitment of resources. It is a very expensive undertaking, and it requires a long-term investment in people and technology, as well as large ongoing costs. Generally, very few financial professionals will say that they are against the concept of risk management. But it is the actions that matter, not the sentiment.

Senior management must buy in and constantly demonstrate their support for a vigorous independent risk management group to succeed. A team of professional risk managers with substantial subject matter expertise and strong communication skills is critical in order for the risk management process to have impact. Risk managers need to have the skills required to garner the respect of their institution's risk takers and senior managers, and organizational career paths need to be created to provide necessary rewards to attract and retain top-level talent.

A significant investment in analytics and information management technology is also required to develop risk metrics, leverage risk managers and to create a reliable information utility that can be trusted across the organization. Institutions need to avoid multiple systems that create internal information wars that result in the inability to make and enforce decisions. Inevitably, this will require strong support by senior management, as in many instances, the value of a nuance of improvement in accuracy or theoretical elegance to the immediate users will often seem exceedingly important, even though maintaining a "tower of Babel" degrades an organization's ability to be decisive. Accessing and using information must be fast and easy in order for it to be useful on a regular basis. Having a risk management team and an efficient information infrastructure in place will allow an organization to respond to unanticipated issues and challenges.

The lesson of the Credit Crisis worth remembering is that while it is impossible to anticipate every potential contingency that may arise, having a professional risk management team and a comprehensive database of portfolio holdings and characteristics will facilitate a fast response when a crisis does strike. While the black swans of Taleb (2007a) are, by definition, unknowable, a strong risk management team can help institutions to mitigate the consequences of those unforeseen events.

3. Conclusion

The Credit Crisis of 2007–2009 has forced market participants to rethink current state-of-the-practice methods in risk management. This paper reviewed some general risk management principles and then highlighted eight lessons worth remembering from the Credit Crisis. These eight lessons need to be incorporated into an institution's risk management process if it is to weather or even prosper in the next financial crisis. Many institutions were forced to learn some of these lessons the hard way, as efficient market based risk models and operational assumptions failed to reveal sizeable sources of risk and illiquid markets impaired the ability to raise cash from asset sales. Furthermore, policy risk is now a major contributor to market volatility, and resources need to be developed to manage these risks as well.

The goal of this paper was not to design more complex analytical models, nor was it to attack quantitative risk management in general. Rather the purpose of this paper was to clearly articulate the lessons worth remembering from the Credit Crisis and outline the steps risk management organizations need to take to be successful in the future. Finally, while the financial markets have recovered from the lows of March 2009 to higher valuation levels, more normalized liquidity and increased stability of major counterparties, market participants should not be lulled into believing that the problems that plagued the Credit Crisis were a one-time event. It is our hope that the risk management principles and lessons discussed in this paper will help institutions to persevere when such problems arise again.

Andrew Lo's quip in the second endnote of this paper that titling any paper "Lessons Learned" by the financial markets would be unduly optimistic, unfortunately, contains a lot of wisdom and reflects an accurate read of the history of financial markets. The historical record is not encouraging.[59] In fact, the very existence of several detailed histories of financial crises demonstrates the repeatability of these crises across time. The writings during and about the Crash of 1907, the Great Depression or even the more recent Long-Term Capital Management Crisis seemed very contemporary when read during the Credit Crisis of 2007–2009. Perhaps it would, therefore, still be an ambitious but reasonable aspiration to hope that the financial community, or at least its current living and practicing members, do retain the memories of this recent bout of turbulence rather than being forced to suffer again, at perhaps an even greater cost to society. If we are fortunate enough to skip a generation before reliving a period like the Credit Crisis of 2007–2009, then all the work done by the numerous commentators and analysts of this period would not have been in vain.

Endnotes

1 The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views and opinions of BlackRock, Inc. The authors would especially like to thank David Greenberg for his detailed and insightful comments. In addition, Maurizio Fercone, Sally Gordon, Sharon Greenberg, Dapeng Hu, Steve Buller, Ron Kahn, Ken Liow, Quintin Price, David Martin, Russell Maddox, Carol Carter, Lev Dynkin and Ed Fishwick made useful suggestions.

2 The title of this paper was originally "Lessons Learned from the Credit Crisis of 2007–2009," but as suggested by Andrew Lo in an email quip, such a title might be an overly optimistic assertion.

3 Vice Chairman and Chief Risk Officer, BlackRock, Inc.

4 Associate, Risk & Quantitative Analysis, BlackRock, Inc.

5 Akerlof and Shiller (2008) make a more fundamental critique of efficient market based models in general by arguing that most economic fluctuations are the result of "animal spirits" and not the result of optimizing behavior by rational, self-interested economic agents.

6 See Wood (2008) for additional discussion on the debate between those advocating a return to "common sense" risk management and those in favor of traditional quantitative risk management.

7 See Thomas and Pearle (2008) for additional details on insider claims that executives at WaMu repeatedly ignored warnings raised by internal risk managers.

8 See Foroohar and Bhaktavatsalam (2009) and Kutler (2009). This assertion is also based on the authors' direct observations at BlackRock. Mr. Golub was a founding partner of the firm now known as BlackRock, Inc.

9 See Buy-Side Managers Forum and Capital Market Risk Advisors (2008) for more details on risk management principles.

10 From an email sent to the authors by Quintin Price, CIO of EMEA Equities, BlackRock, Inc.

11 Sicart (2007) summarizes the "Ludic Fallacy" of Taleb (2007a) as "the misuse of games to model real-life situations." The misused game in this context is the risk model.

12 See Tett (2009: P. 129-142), for additional details.

13 Basel Committee on Banking Supervision uses the same phrase based upon the observations that "a liquidity shortfall at a single institution can have system-wide repercussions" (2008; P.7). In this paper, however, the focus is solely on the survival of a particular institution.

14 See the Federal Deposit Insurance Corporation (FDIC) Press Releases (2009), Federal Reserve Monetary Policy Releases (2009), and US Department of the Treasury Financial Markets Press Releases (2009) for the latest details on several important government programs.

15 Arguably, the collapse of Long Term Capital Management (LTCM) in 1998 demonstrated how quickly liquidity could collapse, although that phenomenon also showed how quickly the markets recovered. For whatever reason, it did not appear that markets remembered the lessons of LTCM.

16 See Satow (2008) for additional evidence that changes in SEC regulations also contributed to increased leverage at financial institutions.

17 Sometimes, the term fundamental value is used as well to get at the underlying value of an asset which might be different from the value assigned to the asset by the market. Fox (2009) provides an entertaining history and debate about the critiques and defenses of the EMH.

18 See, for example, De Long et al. (1990), Lakonishok et al. (1991) and Shleifer and Vishny (1997).

19 See Van Eck Global (2009) and LaCapra (2009) for additional details on the dislocation in market prices for pre-refunded municipal bonds and SPACs.

20 The authors had direct firsthand exposure to the "no bid" aspect of many markets during the Credit Crisis. There are times when seeing is believing, and we are bearing witness to this type of market breakdown.

21 These bonds are said to "have gone to bond heaven."

22 Note that in 2008 the FASB published a staff position paper in order to help clarify FAS 157 which was originally issued in 2006.

23 From Smith (2008).

24 See Lo, Petrov and Wierzbicki (2003) for an example of one of the few models that explicitly includes liquidity into the portfolio optimization process.

25 Source: The Yale Endowment (2008).

26 See Swensen (2009; P. 53-77) for additional details.

27 By comparison, the S&P 500 had an annual total return of 10.4% from 6/30/88-6/30/08 and 2.9% for 6/30/98-6/30/08.

28 Source: Moody's and authors' calculation.

29 See Copeland and Galai (1983) and Glosten and Milgrom (1985) for examples of models that explicitly study the interaction of informed investors, liquidity traders and market makers on bid-ask spreads.

30 It should also be noted that market gyrations that significantly impair expert investors are usually correlated with other factors that result in asset underperformance such as increased volatility, increased risk aversion, and a breakdown of widely used models. The purpose of this section is not to deny the existence of these other factors but rather to emphasize the large impact that expert investors have on the liquidity of complex markets.

31 Source: Monthly index return data from Barclays Capital and authors' calculations.

32 "Excess" kurtosis is a statistical measure of the peakedness, and hence fatness of tails, of a distribution relative to the normal distribution. As shown here, large values are consistent with a high degree of extreme upside and downside moves in returns.

33 See for instance Bullock (2008), Fortado and Cahill (2009), Desmond (2008), Goldstein (2008) and Hyuga et al. (2008) for details on the various counterparties and legal problems that plagued the Lehman Brothers' bankruptcy.

34 Source: Kiel (2008).

35 From 7/31/2009-8/31/1999, the monthly return correlation between the Treasury Index and ABS and CMBS indices was 0.25 and 0.23 respectively.

36 In addition to liquidity, other factors compounded the negative performance of the AUD/JPY carry trade. For instance, the flight to quality trade of fall 2008 saw many investors move into lower-yielding, but more shock resistant currencies like the JPY and USD.

37 Source: Bloomberg and authors' calculations.

38 Source: BlackRock. Data are for illustrative purposes only and do not represent the positions of any actual BlackRock portfolios.

39 Source: BlackRock. Data are for illustrative purposes only and do not represent the actual liquidity demands of any BlackRock portfolios.

40 Several market observers including Hurtado (2009), Voreacos and Kary (2008) and Mnyanda and Pan (2008) have cited the July 2007 collapse of two Bear Stearns hedge funds, the High-Grade Structured Credit Fund and the High-Grade Structured Credit Enhanced Leveraged Fund as the start of the Credit Crisis of 2007 – 2009.

41 The Federal Bureau of Investigation's 2006, 2007 and 2008 Mortgage Fraud Reports provide an excellent review of the various mortgage related crimes that became increasingly prevalent in the run-up to the Credit Crisis of 2007–2009.

42 Source: Securities Industry and Financial Markets Association (2008) and authors' calculation.

43 Refer to Hernandez (2008) and Mildenberg and Freifeld (2008) for additional information on mortgage fraud investigations involving Countrywide Financial Corporation.

44 Source: Countrywide Home Loans Servicing (2007) and authors' calculations.

45 FICO scores are a metric developed by the Fair Isaac Corporation to help measure the credit worthiness of a borrower. FICO scores range between 300 – 850. Borrowers with FICO scores above 720 are generally considered to be prime borrowers, while FICO scores above 680 are considered near prime or Alt-A and borrowers below 620 are typically classified as subprime.

46 Source: Bloomberg.

47 Source: Countrywide Home Loans Servicing (2007), Bordia et al. (2009) and authors' calculation.

48 Source: Data on structured finance are from Coval, Jurek, and Stafford (2008) and correspond to ratings as of mid-2007. Data on corporations are from Salas (2006) and date to August 7, 2006. Data on sovereign ratings are from McCormack (2006) and date to October 6, 2006. However, it should be noted that unlike corporations, sovereign nations and municipalities, every structured finance deal will have some AAA-rated securities that are offered. In fact, the purpose of structured finance is to restructure the cash flows of the underlying assets such that a range of risk levels from AAA to equity tranches and varying maturities can be created to suit investor needs.

49 Source: Bloomberg.

50 Please see Pittman (2008), Glover (2008), Moses (2008) and TrowBridge and Mider (2008) for additional information on some of the losses incurred by banks due to bond insurer downgrades and defaults.

51 See Greenspan (2005) for more details.

52 Source: BlackRock.

53 This particular risk index is used internally at BlackRock and is a slightly modified version of the "Market Risk Sentiment Index" from the Lehman Brothers Global Foreign Exchange Research of Park, McCormick and Jiltsov (2007).

54 Source: Underlying data are from Bloomberg and calculations are done internally at BlackRock. Risk Appetite index red bands represent the average +/- 1 standard deviation over the last seven years. Risk factor red bands represent the average +/- 1 standard deviation over the last three months.

55 Source: BlackRock.

56 Source: BlackRock. Data are for illustrative purposes only and do not represent the actual positions of any BlackRock portfolios.

57 Source: BlackRock and authors' calculations.

58 See Lynch (2008) or US Department of Housing and Urban Development for additional details on the Housing and Economic Recovery Act.

59 See, for instance, Kindleberger (1978), Galbraith (1997), Bruner and Carr (2007) or Lowenstein (2000).

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Appendix

Table A.1: US Policy Changes September 2008–July 2009

Date	Change in Policy
09/07/08	FNM and FRE placed into conservatorship by Federal Housing Finance Authority and US Treasury
09/17/08	Federal Reserve takes 80% stake in AIG in return for $85 billion loan
09/19/08	Treasury provides $50 billion insurance program for money market funds
09/19/08	Fed establishes ABCP liquidity facility for money market funds
09/19/08	Governments worldwide announce short-selling restrictions
09/25/08	WAMU seized by FDIC; assets sold to JPMorgan for $1.9 billion
09/29/08	Citigroup purchases Wachovia with $2.16 billion FDIC guarantee; subsequent private transaction with Wells Fargo announced
10/03/08	US Congress passes Troubled Asset Relief Program (TARP) legislation authorizing Treasury to purchase up to $700 billion in assets
10/07/08	Fed announces the Commercial Paper Funding Facility to buy CP directly from eligible companies
10/13/08	US government announces equity investments aggregating $125 billion in Citibank, JPMorgan, Wells Fargo, Bank of America, The Bank of New York Mellon, Goldman Sachs, Morgan Stanley, State Street and Merrill Lynch
10/22/08	Fed announces $600 billion Money Market Investor Funding Facility (MMIFF) to buy CDs, bank notes and commercial paper from money market funds
11/10/08	Fed and Treasury announce restructuring of AIG financial support; Treasury will purchase $40 billion in preferred shares under TARP and Fed's loan to AIG will be reduced to $60 billion
11/23/08	Citigroup receives $306 billion US government rescue package for losses on toxic assets and $20 billion cash infusion
11/25/08	Fed announces $600 billion purchase of FNMA/FHLMC/GNMA debt and mortgage pass-throughs
11/25/08	Fed creates Term Asset Backed Securities Loan Facility (TALF) to lend $200 billion to holders of high-grade securities with $20 billion back-stop from the TARP
12/19/08	Treasury authorizes loans of up to $13.4 billion for GM and $4 billion for Chrysler from the TARP
12/29/08	Treasury announces equity investments of $5 billion in GMAC and agrees to lend up to $1 billion to GM
12/30/08	Fed announces program to buy $500 billion of agency MBS; hires BlackRock, Goldman, PIMCO and Wellington to implement program
01/16/09	Treasury, Fed and FDIC announce a package of guarantees, liquidity access and capital for Bank of America; Treasury will invest $20 billion of TARP in BofA in exchange for preferred stock

01/16/09	Treasury to lend $1.5 billion from the TARP to Chrysler special purpose entity to finance the extension of new consumer auto loans
02/18/09	President Obama announces The Homeowner Affordability and Stability Plan
02/25/09	Fed, FDIC, Office of the Comptroller of Currency and the Office of Thrift Supervision announce "stress tests" of eligible US banks
03/02/09	Fed and Treasury announce restructuring of AIG financial support; AIG will receive $30 billion from TARP and the Treasury will exchange $40 billion of preferred stock for new preferred shares that resemble common equity; Fed's loan to AIG will be reduced to $25 billion
03/03/09	Treasury and Fed announce the launch of the TALF, lending up to $200 billion to eligible owners of certain AAA-rated ABS securities
03/18/09	Fed purchased $750 billion of agency MBS, bringing total purchases of these securities to $1.25 trillion
03/19/09	Treasury announces Auto Supplier Support Program that will provide up to $5 billion in financing to the auto industry
03/19/09	FDIC completes the sale of IndyMac Federal Bank to One West Bank
03/23/09	Treasury announces details of Public-Private Investment Program, including a Legacy Loans Program and a Legacy Securities Program
03/25/09	Treasury proposes legislation to grant US government authority to put certain institutions into conservatorship to avert systemic risks posed by potential insolvency
04/06/09	Fed announces new swap lines with the BOE, ECB, BOJ and SNB that would enable the provision of foreign currency liquidity by the Fed to US financial institutions
05/01/09	Fed announces CMBS and securities backed by insurance premium finance loans will be eligible collateral under the TALF
05/07/09	Fed releases the results of "stress tests" conducted on the 19 largest US bank holding companies; 10 of the firms fail capital requirements for the more adverse scenario
05/13/09	Treasury proposes amendments to Commodity Exchange Act and securities laws to enhance regulation of OTC derivatives markets
05/19/09	Fed announces certain high-quality legacy CMBS will become eligible collateral under the TALF, starting in July
05/20/09	Obama signs Helping Families Save Their Homes Act of 2009, temporarily raising FDIC deposit insurance from $100,000 to $250,000
05/27/09	FDIC announces number of "problem banks" increased from 252 insured institutions in 4Q08 to 305 in 1Q09
06/01/09	GM and three domestic subsidiaries announce that they have filled for relief under Chapter 11 of US Bankruptcy Code
06/09/09	Treasury announces 10 of largest US financial institutions participating in Capital Purchase Program have met requirements for repayment; Treasury will receive up to $68 billion if they repay

06/17/09	Treasury proposes creation of Financial Services Oversight Council
06/24/09	SEC proposes rule amendments to strengthen regulatory framework of money market funds
06/24/09	Fed extends AMLF, CPFF, PDCF and TSLF through February 1, 2010
06/30/09	Treasury proposes creation of Consumer Financial Protection Agency
07/08/09	Treasury, Fed and FDIC announce details of PPIP; nine firms, including BlackRock, selected to participate as fund managers

Table A.2: International Policy Changes September 2008–May 2009

Date	Change in Policy
09/18/08	Lloyds TSB merges with HBOS in £12.2 billion deal
09/19/08	Governments worldwide announce short-selling restrictions
09/29/08	Irish and Greek governments safeguard securities of six banks and building societies
09/29/08	UK mortgage lender Bradford & Bingley nationalized; assets sold to Santander
09/29/08	German commercial property lender Hypo Real Estate receives €35 billion bailout from government and private banks
09/30/08	Fortis bailed out by Netherlands, Belgium and Luxembourg
09/30/08	Dexia bailed out by Belgium, France and Luxembourg
10/05/08	German, Austrian, Danish and Swedish governments guarantee bank deposits
10/06/08	Germany announces €50 billion plan to save Hypo Real Estate after first rescue attempt fell apart
10/07/08	UK government announces £400 billion rescue package
10/09/08	Iceland faces national bankruptcy as its financial system collapses; seeks loan from Russia
10/10/08	UK government announces investment in HBOS, RBS, Barclays and Lloyds TSB
10/16/08	UBS transfers $60 billion of problem assets to Swiss National Bank and sells CHF 6bn in mandatory convertible notes to the Swiss Federation
10/17/08	Germany passes €500 billion bank bailout
10/19/08	South Korea announces $130 billion financial rescue package to guarantee banks' foreign debts
10/19/08	Dutch government injects €10 billion into ING

10/20/08	Sweden's government announces bank rescue plan
10/20/08	Ethias to receive €1.5 billion from Belgium government, thus taking a 75% stake in the bank and insurance company
10/27/08	Belgian government injects €3.5 billion into KBC Groep to boost solvency in insurance and banking units
10/28/08	Dutch government injects €3.0 billion into Aegon
10/29/08	International Monetary Fund (IMF) announces creation of short-term liquidity facility for market-access countries
11/03/08	Austria takes over Kommunalkredit, Dexia and Volksbanken Group
11/06/08	IMF approves $16.4 billion loan to Ukraine
11/09/08	China sets a two-year $586 billion stimulus package
11/10/08	Carnegie, a Swedish investment bank, loses its banking license and is under supervision of the national debt office
11/19/08	IMF approves $2.1 billion loan for Iceland
11/25/08	IMF approves $7.6 billion loan for Pakistan
11/26/08	European Commission unveils €200 billion economic recovery plan
11/28/08	Bayerische Landesbank to receive €10 billion in capital from Bavaria (€7 billion) and SoFFin (€3 billion)
11/30/08	HSH Nordbank receives a guarantee of up to €30 billion in new debt from SoFFin (German stabilization fund)
12/11/08	French government injects €10.5 billion in preference shares into its six largest banks
12/15/08	French government pledges €1.0 billion in aid to Renault and Peugeot
12/19/08	Commerzbank receives €8.2 billion via silent participations from SoFFin and €15 billion guarantee of new debt issuance
12/21/08	Irish government announces to inject €7 billion into Allied Irish Banks, Bank of Ireland and Anglo Irish Bank
01/03/09	Austrian government takes over Bank Medici
01/08/09	Commerzbank receives €10 billion from SoFFin
01/13/09	German government announces economic stimulus package worth €50 billion

01/14/09	UK government announces plan to guarantee up to £20 billion of loans to small and medium-sized firms
01/20/09	UK government called for the complete nationalization of Lloyds and Royal Bank of Scotland
01/21/09	French government to put €6 billion in auto industry
01/31/09	Japan unveils $17 billion Asian aid package
02/02/09	French government unveils a series of measures worth €26 billion
02/03/09	Australian government announced a AUD$42 billion stimulus plan
03/02/09	HSBC to raise £12.5 billion from shareholders
03/13/09	Australian bank Babcock & Brown enter voluntary administration due to $3 billion of debt
03/17/09	BOJ announces JPY 1 trillion subordinated loan program
03/27/09	Japan extends short-sale restrictions to July
04/02/09	G20 leaders agree to tackle global crisis with $1.1 trillion measures
04/06/09	Japan plans to implement another stimulus plan of over JPY 10 trillion ($99 billion)
04/07/09	Irish government plans to swap government bonds for €90 billion face value of toxic assets
04/11/09	German finance minister proposes "bad bank" plan to keep toxic assets on the books, but will take illiquid assets
04/21/09	Indian central bank cuts a key interest rate to boost economy
05/07/09	ECB announces plans to buy roughly €60 billion of covered bonds and lends banks unlimited funds for up to 12 months
05/21/09	S&P lowers outlook on UK government debt from stable to negative
05/28/09	Swedish government announces expansion of SEK purchases against the EUR by SEK 35 billion to 50 billion

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