

mathématiciens! Pour ma part, je reste très ferme sur ma position de principe, exposée dans mon article de la *Gazette* d'octobre 2008 : les probabilistes doivent « rester à leur place », c'est-à-dire essayer de comprendre (et faire comprendre) les phénomènes aléatoires mis en œuvre dans ce domaine, et dans beaucoup d'autres, et ne pas « coller » au business bancaire, mais bien au contraire, jouer un rôle de sentinelle en affirmant haut et fort que tel ou tel produit financier est déraisonnable (sont visés ici les CDO et CDO 2). Cette profonde crise pourra peut-être permettre d'élaborer quelques principes de bonne conduite des uns et des autres, et aussi de montrer qu'une fois de plus, chercher à faire progresser la connaissance dans des domaines complexes (ici, le Hasard) peut amener assez rapidement à la chasse aux sorcières...

N.B. : Parmi les suggestions que je faisais en avril-mai 2008, il y avait l'idée d'un numerus clausus pour les apprentis « quants ». On m'a alors expliqué que c'était une mauvaise idée! Je pense le contraire, et que la France a besoin de spécialistes de l'aléatoire qui soient opérationnels dans bien d'autres branches appliquées.

Un article moins technique, destiné au journal *Le Monde*, ayant pour coauteurs J.-P. Kahane, D. Talay et moi-même est actuellement en préparation à ce jour (21 novembre 2008). Il traitera de façon plus générale des relations entre mathématiques et applications au monde réel.

The Financial Meltdown¹

Philip Protter²

How did we get in this mess?

To begin we go back to the great depression of the 1930s. Banks had undergone massive bank failures, leading to mistrust of the entire banking system, a crisis in liquidity. The government of FDR helped to solve this problem, and a key component of the solution was the Glass-Steagall act of 1933. Glass-Steagall created the FDIC which insured small depositors in the banking system through a Federal guarantee, and regulated interest rates banks could offer to depositors; it also prohibited a bank holding company from owning other financial companies.

Regulations are typically created when a problem affecting industry or society cannot be solved by the normal functioning of laissez-faire capitalism. An example is pollution: a company that chooses to behave well and incur the extra cost of not polluting the air and water is at a competitive disadvantage to a company that does pollute. Hence in a highly competitive sector, all similar companies are forced to pollute to remain competitive; if the government steps in and stops all of them from polluting by legal action with appropriate penalties, then none of them gain an edge by polluting, and everyone is better off. In banking the role of controlling pollution,

¹ Texte publié dans le numéro 87 de *MATAPLI*, le bulletin de liaison de la Société de Mathématiques Appliquées et Industrielles.

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by analogy, is that of controlling capital reserves. It is costly for banks to maintain capital reserves, but the government (and the international banking system with headquarters in Basel, Switzerland) require banks to maintain capital reserves, and the reserve requirements are roughly proportional to the amount of capital the banks have at risk. Without this requirement, the banks could make more money, but they would also be more likely to fail, and there would be less confidence in the banking system, increasing the likelihood of runs on banks. Competition would force many of them to behave this way, so the role of government regulation is essential for the long term health of banks and the banking system.

The repeal of the Glass-Steagall act came in two steps. In the 1970s it became stylish in the United States to favor de-regulation. Many people remember the deregulation of the airline industry in 1978, via the United States Airline Deregulation Act of 1978, under President Carter. The next big step was for the Savings and Loan industry, with the Depository Institutions Deregulation and Monetary Control Act of 1980, under President Reagan. The S&Ls went from being tightly regulated with insured deposits (up to \$100,000 per account), to deregulated with insured deposits. Two things happened:

(1) the directors of S&Ls began to behave in a high risk manner in the search for higher profits, and

(2) unethical people began in effect to steal from the bank³, through many different means; an example was to give loans to people who would put up insufficient or dubious collateral, perhaps in exchange for a kickback.

A highly liquid atmosphere of “easy money” fueled the fire. This eventually led to massive S&L failures, and the necessity of the government (with the FDIC being committed by law) to bail out the depositors, at the expense of the taxpayers. One result was a large shift of wealth from the Midwest and northeastern U.S., to the southwest, where most of the problem S&Ls were located.

One aspect of the deregulation merits special mention. Under strict regulation S&Ls retained mortgage loans they initiated. The profits to the banks came from the difference in interest paid to the depositors and the rates charged to the people with mortgages. After deregulation a new business model emerged: the S&Ls and banks could originate mortgages and then sell them on the open market. The S&Ls would retain the servicing part of the mortgage, and earn through fees: by servicing the mortgages and by origination fees. Others would earn money through the spread in interest rates. This allowed mortgages to be bundled into Asset Backed Securities (hereafter ABS), which provided geographic diversity of a given pool, and therefore less risk due to fluctuations in the local economy. It also provided some insulation from the risk of “mortgage prepayment”, which would effectively end a lucrative arrangement prematurely; the threat of prepayment had made mortgages difficult to market, and the development of ABS securities diluted this risk among the “tranches.” Salomon Brothers became famous for making a market in ABS in the 1980s. What they did was to slice up a mortgage pool of from 4000 to 7000 mortgages, and then to issue bonds based on the slices, which are called “tranches,” the French word for slice. The tranches have a “waterfall,”

³ It is notable perhaps that two public figures who were implicated in the ensuing S&L scandal were Senator John McCain and the son of the then sitting president (and brother of George W.), Neil Bush.

which determines the order in which defaults and prepayments of mortgages are handled. When there is a shortfall of mortgage payments coming in, the equity holders are hit first, then the lowest tranche, and on up to the highest tranche, often called the senior tranche, or "super-senior" tranche. This meant that, in theory, the investors in the super senior tranche would almost never get hit, and such a tranche was a very safe investment; hence the rate of interest the creator of these bonds would have to offer for the super-seniors was small, whereas the rates of interest one had to offer for more risky bonds naturally increased with the perceived risk involved. But in any event, the ABS securities of the 1980s were backed by traditional mortgages, and therefore relatively safe investments for all concerned. The senior tranches were also safe from the threat of prepayment. These ABS securities became very popular, and since Salomon had a monopoly on the market at the beginning, Salomon Brothers prospered mightily.

The second step in the repeal of the Glass-Steagall act came with the Gramm-Leach-Bliley act of 1999⁴, signed by President Clinton, which ended the legal prohibition of bank holding companies from owning other financial companies. In a sense this was a bill that merely caught up with reality, as the walls were already breaking down and the regulators were doing little or nothing to stop it from happening. However a different ideological climate might have put a brake on the process, rather than legitimize it and give a green light for more merging of the roles of the financial industry.

At this point it is important to bring in the issue of incentive conflict. The most dramatic example of abuse has occurred with executive pay, or executive compensation as it is more properly known. While this is only a small part of the incentive conflict picture, it helped to set the tone for a basic degradation of ethical behavior. We will not give a history of executive compensation here, but instead point out that a major change began in the early 1970s, in response to the feeling that managers of large companies had lost sight of the interests of shareholders who are, after all, the owners of the firm. In an effort to align their incentives with those of the shareholder, executive compensation was altered to include stock options for executives which were in the money (i.e., actually worth something) only if stock prices rose in the short term. This led to a huge increase in executive pay: for example in 1970 average executive pay was 40 times more than average worker pay, while by 1979, the top 25 CEOs were making over \$1 million a year; by 2000 average top CEO compensation was 1000 times average worker pay, and by 2006 the top 25 CEOs ranged in compensation from \$42 million to \$636 million for one year⁵. Of course, it was not just the CEOs who benefited from high compensation: the wealth was spread throughout management and even to some privileged workers, especially so in the financial industry. The system of bonuses was largely responsible for this; they supplemented the base salary, and in most cases far outstripped the base salary, becoming the primary means of compensation. The system of bonuses focused the workforce of companies on short term performance and short term returns; very few people, if any, were looking at the long term health of a company, but rather looking at how to maximize the profits they could make for the company (and therefore their bonuses) in the short

⁴ Senator Gramm is a key economic advisor to Senator McCain.

⁵ Richard Fuld Jr. of the now bankrupt Lehman Brothers "earned" \$54 million in 2006

term (with short term meaning at most a year, usually less). How could companies afford huge executive compensation levels and bonuses throughout much of the higher echelons of a firm, even when in some cases the firm was losing money? The answer is by watering down the stock through the issuance of options, and therefore reducing the value of shareholders, these excessive returns were made possible. Since many shareholders were institutional investors representing pension and retirement funds, the possible outcry over such a transfer of wealth was muted by the dilution of ownership, enabling the greed of management of the 1990s and the current decade. However this led to a moral hazard: in principle (although this too was abused), excessive compensation was tied to how much a stock's price rose in the short term. This created an incentive to manipulate the information given to stock analysts and auditors who certified as true such information. This dispersal of information, the main control over nefarious behavior, was not regulated; instead the market regulated itself through the system of audits, done by private, for-profit companies, such as Arthur Andersen. An incentive conflict arose, since companies would hire auditors as consultants, and often a person's consultant income would be more important than his income as an employee of a large audit firm. It was this conflation of a desire to keep a firm's stock price rising, plus the incentive problems of auditors, together with the laissez faire attitude of the government, which led to the Enron debacle, and others like it (Worldcom, Global Crossing, Adelphia, Tyco, etc.)

After the Gramm-Leach-Bliley act the current decade of the year 2000 became wild. Just as the five large audit firms supervise the integrity of financial reports of companies and are not regulated by the government, so too the three large ratings agencies (Moody's, Standard and Poor, and Fitch) are unregulated, and they supervise the integrity of bonds, including those coming from ABS, CDOs, and the like. And just as the audit firms had conflicts of interest by also consulting for the firms they audited, so too did the ratings agencies. It was very important for the senior tranche of an ABS to be rated AAA. There are two reasons for this: the first is that some institutional investors have a large portion of their investments restricted to investment grade rated objects, and AAA rated investments are even better than investment grade: they are supposed to be as safe as investing in treasury bills; these include insurance companies, banks, pension funds, retirement funds, and university endowments. The second reason is that when a bank makes a risky investment, it needs to set aside a capital reserve equal to a percentage of the money at risk; the more the risk, the more is set aside. This is costly to banks, and therefore banks want always to minimize the capital reserves to that required by regulation. (This is what overnight loans to banks are: if a bank has excess capital reserves one day, it can lend it overnight [for a fee] to a bank which has too little, so that both banks are in compliance.) A huge loophole in this regulation is that no capital needs to be set aside if the investment is AAA, since it is then essentially totally safe. The downside is that returns are typically very low with AAA investments, since the risk taken is so low.

When the standards for obtaining a mortgage began to degrade, people realized that the typical risk of holding mortgage backed securities had increased, and so the investors who organized ABS securities had to offer higher interest rates to attract takers. The degradation took place when deregulation allowed practically anyone

(in addition to the usual sources such as banks and savings and loans) to write mortgages and then sell them to the secondary markets to form ABS securities. Large fees for the sellers of mortgages encouraged the practice. Corruption and incompetence became common: for example, at some times mortgagees did not have to document claimed income levels, nor other outstanding debts (such as credit card loans, auto loans, gambling debts, etc.), and/or appraisals of homes were lax as well. This led to an easy route to fraud: person A buys an \$80,000 home and then sells it to an accomplice person B for \$300,000. The second buyer of the home, via his mortgage, soon defaults, leaving the underwriters (now diffused through ABS securities) to sell a \$300,000 home worth only \$80,000. Moreover person B might not have even needed to make a down payment, having obtained a "piggy back loan" for the missing 10% or 20% customary down payment, leaving him with no equity at risk in the deal. He then splits the profits with his accomplice, person A. This tactic, practiced in quantity, can lead to large losses. And this is only one concrete example of what was going on. These tactics were available due to the acceptability of "subprime" mortgages. Subprime mortgages became a way to continue the life of the housing bubble. Indeed, some see the subprime mortgage phenomenon as even creating the housing bubble, or at a minimum causing its acceleration. As demand began to falter for the ever more expensive real estate market, even with low interest rates and high liquidity bankrolled by a (very) relaxed federal reserve, customers who could no longer afford housing were enabled by unrealistically low "teaser rates" for adjustable rate mortgages which would "re-set" in two or three years to create prohibitively large payment requirements. People were willing to take such deals for three reasons: living in a house became as affordable in some cases as renting an apartment, via the teaser rates and no down payment requirements; second, since the price of houses continued to rise, when the mortgage eventually reset at a high level, one could simply prepay, along with the penalty for prepayment (if any), by obtaining new financing and a new teaser rate, and increasing the mortgage size (since the home was now worth more), which could even include the penalty for prepayment as well as some spending money; third, people could buy second homes, or speculative properties, or simply try to arbitrage the banks by buying properties at low teaser rates and selling them for a tidy profit when the rates reset, because the housing prices rose.

The end of the bubble ruined the party.

What led to the degradation of the mortgage selling standards was a relaxation of regulations, the necessity of such to continue the housing bubble, and especially a large and incessant demand for the senior tranches of ABS securities, once they began to pay significantly higher rates than treasury bills would pay. Due to the lack of capital reserves loophole, these became a source of large profits to banks, investment houses, and others. Soon the demand could not keep up with supply: there was simply too much demand for the quantity of new mortgages being written. This led to the creation of CDOs, the acronym for collateralized debt obligations. The problem was that while the senior tranches were easily saleable, the other tranches were much more risky, with the equity tranche (usually kept by the creator of the ABS) being the riskiest. The CDOs repackaged the bonds from the lower tranches of the ABS; so that the bonds from an ABS were the

collateral behind the CDOs. What happened was that a clever capitalist would repackage these lower grade bonds into a new set of tranches, which had its own "senior tranche." The ratings agencies were using historical standards to rate the CDOs; but the huge increase in subprime mortgages was unprecedented, so in effect the ratings agencies were complacently using an out of date model to rate new, much more risky products. Due to their high risk, the senior tranches of the CDOs commanded a higher interest rate, but due to the incentive conflicts of the ratings agencies, coupled with their outmoded methodology, they were "able" to give them the highest rating of AAA, which we remind the reader meant they were essentially as safe as treasury bills. Everyone knew (or should have known) that these bonds were not comparable to treasuries, but having the AAA rating meant the banks and investment houses could get a high rate of return and still have no capital reserve requirements, leading to enormous profits.

It gets worse: demand for these highly profitable CDO securities led some capitalists to repackage the lower tranche bonds (not the senior tranches which were easy to sell) into CDOs backed by CDOs. These were known as "CDO squared," denoted *CDO*². These were even more dubious, backed by the lower grade bonds of a CDO, which were of less quality even than the lower grade bonds of ABS. Sometimes even the equity tranches of ABS were placed into CDOs and *CDO*²s. Yet the creators of *CDO*²s were nevertheless able to get the ratings agencies to rate the senior tranches of these dubious derivative securities of derivative securities, as AAA. A key element in getting these coveted ratings was the role of monoline insurance companies⁶. These insurance companies were only too happy to provide insurance for AAA securities: it was seen as a perfect business model, where they were paid recurring fees for providing the insurance, with so little risk that there was no need to hedge effectively against the possibility of default. The AAA ratings of these quite high risk products were provided by the incentive conflicted ratings companies, with the rationalization that they were insured by these monoline insurance companies. The CDOs were snapped up by eager banks and investment houses, not just in the US but also in Europe and Japan.

At this point one may well ask: Didn't the bankers know better? Their mothers' dictum that "if it is too good to be true, it must not be true" should have applied. Why they persisted to buy these until the bitter end can be explained by the incentive system of the banks: the remuneration of the traders and others were based on a bonus system, creating incentive for short term gains no matter the risk to the company. And traders and the banks themselves were profiting mightily from these products for over 2 years until the fall. Not only did senior partners of the banks and firms make tens of millions of dollars annually, but the wealth was spread around, so that many ordinary employees could earn a million dollars or more a year with these trades. The basis for performance was three month periods: if nothing happened within 3 months, it was someone else's problem. With everyone thinking this way, it is inevitable that someone will be holding the "hot potato" at the end. As it turned out, everyone had more than enough potatoes to go around. And if a responsible trader refused to participate, he or she would be ostracized

⁶ Conventional insurance companies are prohibited from insuring financial products such as CDOs, by regulation. A monoline insurance company exists expressly to provide such insurance: examples are the now failed ACA and a subsidiary of the insurance giant AIG.

by his co-workers for not making enough money for the group, and possibly not participate fully in the enormous bonuses being handed out. How long can one person resist within that sort of crucible environment? There are stories of the people who created the CDOs sleeping in the building, and living on take out pizza, so that more and more money could be made as they continued to create CDOs around the clock to fulfill demand.

Thus we see that the combination of a relaxed regulatory environment (thanks to congress and the administration's "business friendly" attitude, especially reflected by the SEC and the Federal Reserve), a degradation of mortgage selling standards in a non regulated environment, the presence of a housing bubble and the large increase of subprime mortgages, a dubious incentive structure within the banks, and an outmoded methodology coupled with a dubious incentive structure for the ratings agencies, all placed into a climate of excessive greed magnified by extremely high executive compensation levels, combined to lead to the current banking and credit crisis. Once these factors are all understood, a recipe for correction seems fairly clear. Whether or not it will be heeded remains to be seen.