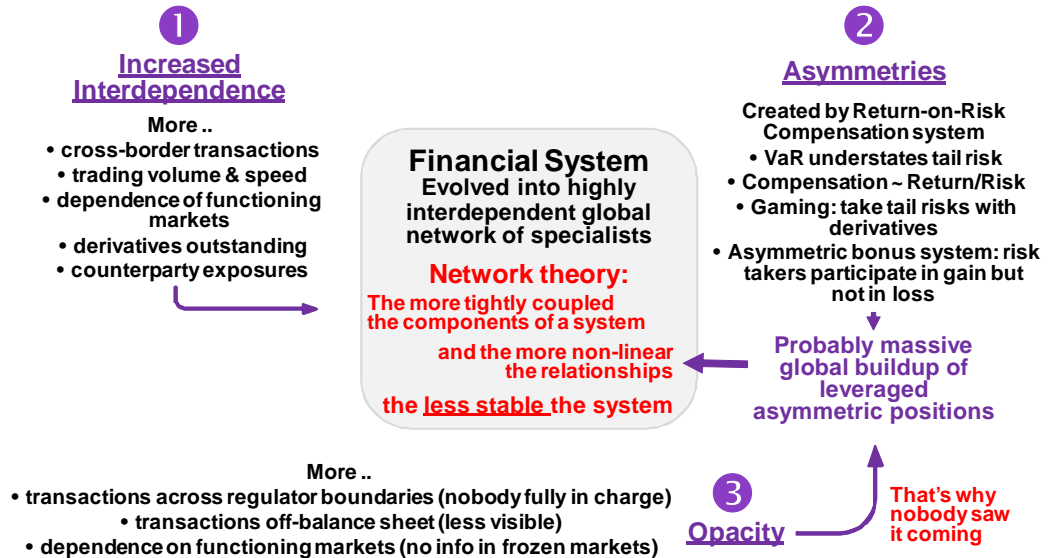


# What has happened in the financial markets?

There is a growing consensus that the current financial crisis is a consequence of years of excessive money supply and deteriorating lending standards. But why an almost simultaneous global economic collapse of the financial systems – why did the “excesses” grow unnoticed by most for such a long time, why did policy makers and regulators not raise red flags earlier, why did investors, traders and lenders continue their business with abandon?

The purpose of this document is to provide a systems engineer's perspective on what may have been a significant contributor to the sudden meltdown of the financial markets. The gist of the argument goes as follows:



1. **Interdependence:** Financial institutions of all types have become far more interdependent around the world, and their interdependencies have become non-linear and opaque. Engineers know that complex systems tend to become unstable the tighter and the more non-linear the coupling become between the systems' components.
2. **Asymmetries:** Risk takers of all kinds were compensated increasingly on “return-on-risks” with returns calculated based on marking positions to market, daily. To game this incentive system they took on more asymmetric risks (frequent small gains, rare huge losses) for two reasons:
  - a. the simpler risk methodologies (VaR) underestimate the downside risks and
  - b. they participate with incentives in gains and switch employers when the rare loss hits.
 This may explain why very large amounts of asymmetric risks were built up throughout the system. Asymmetric payoffs create non-linear behaviors.
3. **Opaqueness:** Regulators, investors and boards should have focused not only on the risks in individual institutions but also on network risks. They neglected network risk for two reasons
  - a. Current financial accounting does not provide good insights into off-balance sheet items like derivatives, guarantees and complex financial instruments, and
  - b. No single regulator has a mandate to look at the entire global network. The global financial system is regulated by a patchwork of cooperating national entities.

Thus the network risks remained opaque and unattended

When the first big losses became apparent (U.S. sub-prime mortgages) the tight linkages created a series of cascading failures bringing down a growing circle of financial institutions and shutting down markets – similar to what we experience in electric power-nets with brown-outs or black-outs.

The remainder of this note describes A) how the financial markets have morphed into a less stable system of highly interdependent players, B) who we can possibly blame for the meltdown, and C) what to expect next including a proposal for a brainstorming session.

## A. The ecosystem of finance has changed

In the past banks were the principal intermediaries of money and the national regulators supervised them. Their sources of funds (liabilities) were local customer deposits, their uses (assets) loans. Regulators controlled the financial system by a) allowing only banks to accept deposits, b) specifying the minimum required capital banks must hold and c) influencing interest rates by injecting or removing funds from the banking system. This simple system has changed dramatically:

1. **Disintermediation:** Today there are many different types of entities intermediating money, and many are outside the purview of the bank regulators. Other regulators came to the party, creating an **environment in which nobody has total regulatory control and responsibility**. Examples of new intermediaries are: money market funds (taking in short-term deposits and investing in short-term commercial paper (CP)), insurance companies providing investment contracts to savers camouflaged as insurance policies, special purpose financing vehicles auctioning CP and taking loans off banks' balance sheets.
2. **Derivatives:** Today financial statements do not provide much insights into derivative positions, thus we lost transparency. The invention of derivatives allowed us to separate funding and liquidity from risks: derivatives move market and credit risks from one institution to another, across national boundaries. Derivatives made the financial markets far more efficient. They allowed us to spread risks and so absorb short-term local shocks and to add global risk taking capacity through diversification. However, derivatives dramatically increased the **interdependencies between parties across the globe** and they did so in an **opaque** way because they don't belong on a balance sheet – today's prevalent perspective on financial strength. Today, the outstandings of derivatives, however measured, far outstrips the outstandings of deposits and securities globally.
3. **Mark-to-market valuation and liquidity:** The relentless push to better measure financial performance over ever shorter-term intervals increased the need to mark-to-market every single financial asset. When markets existed - even very shallow ones - the price of the latest transaction would be interpreted as the best estimate for much larger inventories. When markets did not exist, models would estimate implied market values based on related markets. These **market values were taken as truth and observed changes in market values were used to estimate risk**. Over the last six months, liquidity in many markets disappeared, so we are at a loss to value financial assets and risks – and this is deadly in a world of highly interconnected counterparties depending on efficient markets: visibility on who is a good or a bad counterparty disappears..
4. **Talent and compensation:** the intense focus on **market values** allowed us to better "measure" the short-term performance of institutions, departments and individuals and to compensate them accordingly: CEO's through stock options on the value of their firms; professionals on the increase of market value their transactions generated for the firm. This focused the entire financial industry to become much **more transaction-oriented** and attracted a lot of talent playing the game. Furthermore, the game got distorted by the **asymmetry of risks and rewards**: individuals participated in gains, institutions had to absorb big losses while individuals moved on. **The possibility to game the simplistic Value-at-Risk ("VaR") based compensation system** deserves a more detailed explanation:
  - a. **Compensate based on profit/risk:** With the widening acceptance of VaR, many risk takers and businesses were increasingly compensated not alone based on the profits they generated, but on the profits generated divided by the risk they incurred [profits/VaR]. The argument is convincing: a professional who generates more profit with less risk should be compensated higher than a professional with less profits and/or more risk. For this compensation schema to be accepted, risk has to be measured fairly, i.e. in a generally accepted uniform fashion. VaR seemed to be a good simplistic proxy which could be computed for all kinds of financial positions.
  - b. **The preference for highly asymmetric positions:** The fundamental assumption in VaR calculations is that market prices move randomly and can be described with a simple statistic: the "normal" distribution. To game the bonus system based on "profits/VaR",

professionals were incented to construct positions which usually generate small positive profits yet very seldom created large losses – let's call them "asymmetric positions". Why? Because these positions show up as having a very low VaR. This is because the highly unlikely loss tends to get neglected in the VaR calculation based on "normal" distributions. Any trades that generate even small profits at "no" risk are favored by professionals compensated in a "profits/VaR" scheme. Following are two examples of highly asymmetric positions. First, selling far out of the money options: Assume the Euro trades at 1.30 vs. the Dollar and I sell you for a small fee a 1 year option to buy from me Euro85 million for US\$100 million. Clearly this position creates a small profit, the fee, for me as long as the Euro trades above 0.85 – a highly likely outcome. But it can create huge losses should the value of the Euro fall below 0.85. Second example: Credit default insurance. I sell you for a small fee a \$100 million 3-year insurance against the bankruptcy of IBM. Again the chance of a loss for me appears minimal, but if it happens the loss could be very large.

- c. **The asymmetric bonus system:** Risk takers are very highly compensated in good years – they participate with their bonus in the trading profits generated. But in bad years, the worst that can happen to them is no bonus and getting fired – they never participate in the big losses. This creates a misalignment of interests between the risk taker and the employing institution and its shareholders: the risk taker is not as adverse to losses as the institution is and as a consequence takes larger position than would seem prudent and advisable for the institution.

So what? **I believe it is very likely that huge amounts of highly asymmetric position were built up throughout the financial markets unbeknownst to many executives and regulators relying on basic financial and risk reporting systems.** This is because the risk takers were incented to do so with the basic "profit/VaR" - based compensation and the asymmetric bonus system. So, don't blame them. The global scale and the opacity of derivatives reporting made this build up very hard to see for observers and regulators. But these positions greatly increased the instability of the system: they created very large sudden losses which propagated rapidly through the tight linkages between institutions in the developed and emerged markets.

## **B. How did we get to the brink of collapse? Who can we blame?**

We can point the finger in many directions:

**1. Politicians** – regulation cannot be delegated to the market: No regulator was in charge overall. The idea of competing regulatory systems failed. Each regulator focused on overseeing institutions in their assigned space and nobody was responsible for thinking about the consequences of this increasingly interdependent network of institutions and markets. Financial markets have become truly global, but their oversight is intrinsically national (the only fallback – money – is national). Surely some institutions were singled out by their respective regulator as being weaker than others but nobody anticipated the potential instability of the network. While this is being addressed within the US and the European Community, the real question will ultimately be: **who will regulate the world's financial markets as they have become so interconnected?**

**2. Regulators** – regulators adapted slowly to the emergence of securitization and derivatives which made the old regulatory framework based on balance sheets ineffective. After lengthy debate they introduced Basel2 and Solvency2 which were squarely aimed at quantifying risks within individual institutions, if necessary with the help of quantitative models, under "normal" market conditions. They got side-tracked by local complexity of instruments and institutions and did not understand how the incentive systems drove participants to game the risk based regulatory framework. They should have focused on the bigger picture – the increasing potential instability of a network in which the nodes became more interdependent. Basel/Solvency2 **became overly sophisticated solutions addressing the wrong potential problem.**

**3. Management** – the institutions that got hit hardest and early in the crisis were the ones which celebrated deal-making in independent business units the most, and relied on market values and model valuations to control and compensate. The institutions that escaped most harm are the ones that either stuck to their historical expertise and business [assuming it survived] or that had a truly independent risk management function to balance the interests of business units and understood how to read early market signals of distress. Mark-to-“market” and the complex opaque instruments drove **incentive systems which created massive conflicts of interest** between the individuals, institutions, regulators and shareholders.

**4. Boards and Shareholders** – most shareholders in financial institutions got hit hard and were surprised. Boards are blamed for not properly representing shareholders’ interest. Many were blinded by the momentum of short-term financial results based on “market valuation” and transaction fees. **Few understood the lack of transparency, the critical dependence on ever more exotic functioning markets and the increasingly misaligned incentives** diverting executive motivations away from shareholders’ interests. Clearly they will ask for more regulation and more transparent financial disclosure.

This disruption is not the result of failure of a single party, but a systemic failure caused by the increased interdependency of players which built up unnoticed by most. Network theory tells us that stability of complex systems decreases when the linkages become tighter (more interdependent) and when the linkages become more non-linear (behavior of options or complex securities). **The critical risks are not only in individual nodes (i.e. the institutions) but in the network of specialized opaque nodes more tightly linked through non-linear relationships.**

### C. What happens next?

Standing on the abyss is cathartic; the consequences will be significant.

**Short-term:** Heavy-handed intervention of the kind we have seen by the regulators and governments looks like the only feasible solution to stem the loss of confidence. The structural changes are significant. This will create a lot of short-term inefficiencies and arbitrage opportunities which however are hard to exploit because of legal/regulatory uncertainties. Politicians will look for scapegoats among highly paid financial executives and they will push for heavy regulation. Financial markets will become less efficient and more costly as more capital will be required for intermediation and markets for complex derivatives and securities will only slowly reopen. Banks will merge and cut staff in search for economies of scale and savings. It’s back to basics and conservatism – a perfect breeding ground for all the laid-off talent to start more nimble operations and innovate.

**A key question is: how does financial regulation have to change to prevent a reoccurrence of such a crisis. It may be worthwhile to get help from experts outside of the financial markets** – from a wide range of fields with experience which may be relevant to building a better understanding and monitoring the stability of the financial system. We should contemplate to call on academic and practical experts from the following fields:

- **Electric power networks** – how do we monitor the stability of the electric power distribution networks and prevent brown-outs and black-outs?
- **Information networks / internet** – how do we monitor the stability of the global web; how do we balance the loads and adjust to disruptions, how do you defend against attacks?.
- **Intelligence gathering in large networks** – how do you monitor vast amounts of data for exceptions, spreading of viruses, building resilience against?
- **Agriculture** – how do we measure the stability of an agricultural ecosystem; when do specialization, monocultures become too vulnerable, how do you build resilience against diseases?
- **Global Health** – how do you reduce vulnerabilities to pandemics, how do you detect outbreaks of new diseases early and contain them?

- **Biology / Medicine** – what can we learn from observing stable biological systems, interactions of cells and chemicals, cancer-induced breakdowns?
- **Behavioural economics** – how do incentives affect human behavior in conflict and cooperation (Nash equilibrium, Schelling)
- **Electronic gaming** – how do you keep multiparty electronic games (e.g. World of Warcraft) on the internet going, how do you prevent sudden breakdowns, how do you encourage viral distribution and growth in participation?
- **Antiterrorism**. – how do you identify potential targets of terrorists and protect them ? (successful terrorists create vast negative impact with minimal effort)

It may be constructive to convene a 1-day brainstorming session with an academic, a regulatory and a business expert from each of the above fields. The 7 hours could be spent as follows:

**Introductions (30 min):** introducing format, goals and participants

**Sharing Experience (2 hours):** Each expert gives a 5 minute prepared summary of how he/she looks at system stability, how stability is measured and tracked and how breakdowns are best prevented.

**Group discussions #1 - looking for common themes and unique approaches (75 minutes):** 4 groups of 5- 7 experts discuss for 45 minutes each and the report back to the assembly their key findings (3 minutes) with 15 minutes left for discussion in large group.

**Group discussions #2 – providing advice to the financial industry (75 minutes):** 3 groups, each representing either the regulators, the academics or the business experts, discuss for 45 minutes what ideas they picked up from the previous session which may be applicable to the financial industry and report back to the assembly their key recommendations to their counterparts in the financial industry (3 minutes) with 20 minutes left for discussion in large group.

This whole day is **monitored** by a **group of 3 financial industry professionals** (a regulator, an academic and a banker). Their mandate is threefold: 1. To answer any questions on how the financial industry may be different. 2. To take copious notes of the insights and recommendations and 3. To summarize the recommendations and decide whether and how they should be carried forward to the industry.

We need out-of-the-box thinking. Our ability to create new instruments and markets has outpaced our ability to control the system that resulted from these innovations. We need better concepts to describe the risks in the financial system, not just the risks in individual institutions.

**Medium-term:** We will see more regulatory consolidation within countries and more coordination across countries. We will see a significant push for more transparency and methods to reduce network risks: growth of listed markets vs OTC markets; accelerated introduction of netting schemes and central counterparties; more disclosure on derivatives. We will see faster adoption of global financial disclosure standards and we will see the emergence of a new branch of risk management focusing on liquidity risks and stability of networks. The partial nationalizations and the mergers of large institutions into even larger ones will set free a lot of talent which will start new specialist boutiques thus driving continued innovation.

**Long-term:** We will see another crisis, different again. Better early and smaller than late and larger.

Till Guldemann, SunGard, September 22, 2008 (updated through January 5), 2009