

## World Leaders Pledge \$1.1 Trillion for Crisis



LONDON — Struggling to bridge deep divides over how to revive a paralyzed global economy, the leaders of the world's largest economies agreed Thursday to bail out developing countries, stimulate world trade and regulate financial firms more stringently. But [President Obama](#) conceded that there were “no guarantees” that those measures would reverse the biggest global downturn in six decades.

Prime Minister [Gordon Brown](#) of Britain, host of the [Group of 20](#) summit meeting called to fight the crisis, announced at its conclusion that the leaders had committed to \$1.1 trillion in new funds that would greatly increase the capital available to the [International Monetary Fund](#). The goal would be a revival in trade, which is expected to contract this year for the first time in 30 years.

But the combination of loans and guarantees fell short of an injection of fresh fiscal stimuli into the economic bloodstream — the result of a stubborn division between Continental Europe and the United States over whether to act now or wait to see whether existing spending measures took effect.

Moreover, the final accord was far more forceful in addressing the plight of emerging economies that had been sideswiped by the [financial crisis](#) than it was in addressing the deep recession in the largest countries where the crisis began.

The proposed remedies, some critics said, treat some peripheral effects of the crisis rather than its thorniest causes. On the critical question of how to grapple with trillions of dollars in “[toxic assets](#)” clotting the financial system in Europe and the United States, there was a declaration of goals but few specific actions.

Still, the meeting eased fears that leaders would repeat the failure of a similar gathering in 1933, which was followed by a surge of [protectionism](#) that prolonged [the Great Depression](#). It also gave Mr. Obama a high-profile debut on the world stage. He projected contrition about America's role in starting the meltdown, extolled global resolve to find a way to end the downturn and mediated a dispute between the presidents of France and China over tax havens.

“Today, we've learned the lessons of history,” Mr. Obama declared in a news conference in which he was noticeably relaxed, taking questions from journalists from India and China. But he also said that getting more than 20 countries to agree to common steps was particularly hard because “each country has its own quirks.”

The meeting, he said, exemplified the power of developing nations, heralding a new age in which decisions about the future of the global economy will no longer be made by an elite club of Western powers that have set the global rules since the [Bretton Woods](#) agreement in July 1944.

Mr. Brown, who organized the meeting in a hangarlike conference center in London, said: “This is the day the world came together to fight against the global recession. Our message today is clear and certain: we believe that global problems require global solutions.”

The most concrete step was a \$750 billion reinforcement of the resources of the monetary fund, which has emerged from years of waning relevance to become the first responder in this crisis, lending billions of dollars in emergency loans to dozens of countries.

In addition, the leaders agreed to provide \$250 billion in trade credits, needed to finance cross-border trade that has declined roughly 10 percent as a result of the credit crisis and the economic downturn.

Among other steps Mr. Brown detailed were new regulations on hedge funds and rating agencies, as well as a crackdown on tax havens, which will be publicly identified and subjected to sanctions if they do not agree to share tax information with the authorities of other countries. A senior Obama administration official cautioned that the sanctions were “future oriented.”

Stock markets around the world, especially in emerging nations, rose in the hours leading up to the announcement.

In the United States, however, investors seemed less cheered about a deal emerging from the Group of 20 than about an arcane change in American accounting regulations that would make it easier for banks to defer writing down the value of their most troubled toxic assets. Many financial experts had been hoping that world leaders would address how to dispose of those assets rather than leave bankers to use accounting changes to make them appear less crippling.

“The rich countries are in denial about the depth of the problems remaining in their financial sectors,” said Kenneth S. Rogoff, a professor of economics at Harvard. “They want to congratulate themselves for taking all the right steps already, as if the only problem now is how to help emerging markets.”

In the end, the leaders also papered over one of their most public disputes: whether countries around the world should commit to even greater fiscal stimuli than they had already enacted.

France and Germany balked at American pressure, saying their social safety nets accomplished much of the goal. Mr. Obama largely surrendered the point, agreeing to vague wording that allowed nations the leeway of promising to take whatever steps were necessary for “sustained growth.”

The German chancellor, [Angela Merkel](#), lavished praise on Mr. Obama, saying he “pushed very hard to come to concrete solutions and to have a fruitful discussion.”

The Group of 20 did agree on new global rules to govern the pay and bonuses of bankers. The leaders also agreed to “name and shame” countries that erected trade barriers, intended to resist growing protectionist sentiment.

But a European push for sweeping global regulation of the financial markets was blunted, to a large degree, by the United States. While the leaders agreed to create a new Financial Stability Board to monitor the financial system for signs of risks, they stopped well short of giving regulators cross-border authority, something France has long advocated.

Instead, the leaders agreed to more closely coordinate their regulation of “systemically important” financial institutions. They did not, however, agree on a mechanism to resolve cross-border disputes that might arise in the winding down of insolvent banks, an issue that might yet arise if global banks like [Citigroup](#) or [Royal Bank of Scotland](#) fell deeper in trouble.

“The regulatory part was close to a zero,” said Simon Johnson, a professor of economics at the [Massachusetts Institute of Technology](#).

Mr. Johnson said that despite the failure to reach an agreement on more stimulus programs, he considered the meeting a success for Mr. Obama. [Treasury Secretary Timothy F. Geithner](#) had led the push to reinforce the monetary fund, and he won more than analysts had expected.

In addition to its vastly larger financial resources, the monetary fund was given a mandate to act as an early warning system for financial risks.

China is expected to contribute \$40 billion. Japan and the [European Union](#) each pledged \$100 billion. The United States has said it will contribute \$100 billion, too, though that requires Congressional approval.

In addition to \$500 billion in loans, the Group of 20 approved a one-time issuance of \$250 billion in Special Drawing Rights, the synthetic currency of the fund, which will be parceled out to all its 185 members.

Reflecting the rise of China, India and other emerging nations, the leaders called on the fund to overhaul its management by 2011 to better reflect the economic weight of its member states.

“Today is the proof that the I.M.F. is back,” said the fund’s managing director, [Dominique Strauss-Kahn](#).

*Julia Werdigier contributed reporting.*

**The Economic Summit**

In normal times we don't expect a lot from summit meetings. But with the global economy imploding, leaders at Thursday's meeting of the world's top 20 economic powers had an urgent responsibility to come up with concrete policies to fix the global financial system and restore growth. They fell short.

The meeting certainly produced more than the usual photo ops and spin — and its participants did not go away yelling at one another as they have in the past. The leaders pledged to fight protectionism and to help badly battered developing countries and — putting their money where their mouths are — committed \$1 trillion for loans and trade guarantees. The group also agreed to crack down on tax havens and, on a country-by-country basis, impose stricter financial regulations on hedge funds and rating agencies — necessary though insufficient steps to avoid a repeat of the current disaster.

Where they fell dangerously short was their refusal to commit to spend the hundreds of billions of dollars in additional fiscal stimulus that the world economy needs to pull out of its frighteningly steep dive. With consumer spending and business investment collapsing around the world, rich countries are the only ones that have the resources to do what is needed.

European leaders — most notably Germany's chancellor, Angela Merkel — made clear going into the meeting that they were not going to give in on that issue. German politicians are historically afraid of touching off inflation with too much deficit spending. But inflation is not the danger Europe faces today, and German history should make them equally wary of the disastrous consequences of a new depression.

President Obama has rightly warned the Europeans that they cannot count on American consumer spending alone to drive a global recovery. But he apparently decided that a battle would be too destructive.

After years of watching former President George W. Bush hector and alienate this country's closest friends, we were relieved to see Mr. Obama in full diplomatic mode. We fear, however, that this is not the time or the issue on which to hold back. If world growth continues to

decline — and all signs suggest that it will — the president will have to take on this fight soon.

Stimulus spending wasn't the only area of fundamental disagreements. The Europeans came to the meeting stressing the need for comprehensive cross-border regulation of financial markets, participants and products. Mr. Obama and his team seem more committed to domestic regulation than their predecessors — but fiercely resistant to the idea of a global regulator.

The group compromised with its call for more transparency and better early-warning systems for systemic risks. We suspect that it will take considerably more than that to reassure investors that markets are safe.

The world's wealthy nations must come to a common understanding of the causes of this crisis and a common vision of the future role of financial markets. From there, they need to write new rules and regulatory regimes that address the real dangers. In the end, necessary regulation will not be transnational enough for European tastes and too binding for American tastes. When both sides grumble about the result, rather than praise it, you will know that progress is being made.

The British prime minister, Gordon Brown, declared at the meeting's end that "this is the day the world came together to fight back against the global recession." As host, he had to. To pull out of the current crisis, it will take a lot more than was done in London.

# A summit that shows the new balance of power

**New alliances are forming, old ideologies are dying, the world is now a different place.**

Mary Dejevsky looks at the lessons of the G20

April 3, 2009, The Independent

## **Multilateralism and its institutions are back**

Not only did the leaders of the 20 richest countries in the world all find time in their diaries to come to London, but most of the action they announced yesterday is to be channelled through existing international organisations chiefly the IMF and the World Bank. If everyone honours their pledges, institutions that seemed on the verge of redundancy only a few years ago will soon find themselves awash with new cash and new responsibilities. They will be under pressure to restructure themselves in line with their new remit. The Bush-era contempt for the UN and other multilateral forums is a thing of the past. At least for now.

## **The ultra free market is no longer dogma**

In saying as baldly as he did yesterday that "the Washington consensus is over", Gordon Brown effectively rejected, on behalf of the whole G20, the ultra free-market dogmatism that the US and Britain liked to preach after the collapse of communism. The IMF and World Bank had already started to distance themselves from the idea that countries seeking their assistance should be encouraged, or required, to adopt free-market mechanisms on the US model. But the outcome of the London summit is the clearest signal yet that the US model inherited from the Clinton and Bush years will be regarded as one way of doing things, alongside others. In the new world order, economic transparency, accountability and effectiveness will also be considered virtues.

## **The US is becoming just another big country**

We do not know exactly what went on inside the ExCel centre. Beyond it, though, all eyes were on Barack and Michelle Obama. Separately and together, they were the couple the crowds turned out to see. President Obama was the national leader most in demand for bilateral meetings, starting with breakfast, a round of talks and a long-ish press conference at No 10. From what we know about preparations for the summit, and from the communiqués, however, the voice of the United States was one, albeit an influential one, among others.

In London, Mr Obama's celebrity status seems not to have translated into diplomatic weight. This may reflect the "listening" stance he has adopted in contrast to his predecessor's air of certainty. It could reflect the US economic plight or, more prosaically, it could simply be because he has yet to appoint many Treasury and State Department officials. But it could also be a sign of new times. By inclination or by necessity, the post-Bush United States seems to see its place in the world a little differently: less American exceptionalism, more consensus-seeking. In the G20, the presence of China, India and Indonesia, among others, gives a foretaste of a future world order.

## **The special relationship is a thing of the past**

Mr Brown was the first European leader to meet Mr Obama in Washington after his election and the first European leader to receive the new President on his home territory. The small irritations that came to light after the Washington trip the lack of a full-dress press conference, the brevity of the meeting, the presents were all thoroughly laid to rest in London. What was also clear, though, was that Mr Obama exercises his bonhomie without special favours. Britain must get used to the idea of being one friend among many others.

## **The US and Russia pushed the reset button**

Relations between the US and Russia, good or bad, are not going to dominate the new world order. But the poor state of relations in the later Bush years was a liability to both, hindering US diplomacy in several parts of the world and distracting Russian leaders from urgent business at home.

Mr Obama and Mr Medvedev, both lawyers incidentally and of a similar age, struck a new tone at their London meeting. A July summit lies ahead, along with that old stalwart of Soviet days, talks on nuclear arms control, with a view to replacing or extending the START treaty which expires at the end of the year. The US anti-missile installations planned for deployment in Poland and the Czech Republic appear to have been put on hold, as have Russia's counter-deployments in Kaliningrad. The broad smiles on both men's faces at the end of their meeting suggested a cordiality, on a personal level at least, not seen in US-Russian relations for 20 years. It may be too soon to count on a joint approach to Iran, Afghanistan or Iraq. But warmer relations could prevent the sort of stand-off in Georgia last August that came dangerously close to war.

#### **"Old Europe" made its voice heard**

The European Union is often criticised, including by its friends, for not exercising international clout commensurate with its political and economic strength. And the split between "old" and "new" Europe on a plethora of issues, including the US, Russia, economic models and Iraq, was debilitating.

With many "new" Europeans suffering disproportionately from the economic crisis and a new mood radiating from Washington, however, the divisions have narrowed. When the French and German leaders jointly set out their demands for tougher financial regulation on Wednesday, they could claim to be speaking with a European voice. Some even likened them to an opposition. Even if their demarche was mainly directed to their home audiences, it put Europe on the diplomatic map where it is very likely to stay.

#### **China made its shy debut as a rising power**

Right up there with Barack Obama as the international leader most in demand for bilateral meetings was Hu Jintao, President of China. Even so, he kept a low profile; fitting in, saying nothing out of turn. There was an ambivalence that suggested uncertainty about how to handle growing power. Before the summit, China had backed a proposal for a new international reserve currency an idea whose time may yet come. It had also fended off another US demand for it to reduce the trade imbalance by revaluing its currency. In London, China's rise was treated by everyone else as inevitable, if not already a fact. President Hu still seemed desperate not to scare the horses.

#### **Britain has a future as host to the world**

A parochial post script. It was all going to be an ill-tempered disaster; draft communiqués, M. Sarkozy complained, were crossing his desk by the hour. In the event, there were smiles, the sun shone, the roads were clear, there were drinks with the Queen, dinner at Downing Street and an agreement that satisfied even the French. So, not a disaster at all.

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David Brooks, NYT **April 3, 2009**  
OP-ED COLUMNIST

## **Greed and Stupidity**

By **DAVID BROOKS**



What happened to the global economy? We seemed to be chugging along, enjoying moderate business cycles and unprecedented global growth. All of a sudden, all hell broke loose.

There are many theories about what happened, but two general narratives seem to be gaining prominence, which we will call the greed narrative and the stupidity narrative. The two overlap, but they lead to different ways of thinking about where we go from here.

The best single encapsulation of the greed narrative is an essay called “The Quiet Coup,” [by Simon Johnson](#) in The Atlantic (available online now).

Johnson begins with a trend. Between 1973 and 1985, the U.S. financial sector accounted for about 16 percent of domestic corporate profits. In the 1990s, it ranged from 21 percent to 30 percent. This decade, it soared to 41 percent.

In other words, Wall Street got huge. As it got huge, its prestige grew. Its compensation packages grew. Its political power grew as well. Wall Street and Washington merged as a flow of investment bankers went down to the White House and the Treasury Department.

The result was a string of legislation designed to further enhance the freedom and power of finance. Regulations separating commercial and investment banking were repealed. There were major increases in the amount of leverage allowed to investment banks.

The U.S. economy got finance-heavy and finance-mad, and finally collapsed. When it did, the elites did what all elites do. They took care of their own: “Money was used to recapitalize banks, buying shares in them on terms that were grossly favorable to the banks themselves,” Johnson writes.

In short, he argues, the U.S. financial crisis is a bigger version of the crises that have afflicted emerging-market nations for decades. An oligarchy takes control of the nation. The oligarchs get carried away and build an empire on mountains of debt. The whole thing comes crashing down. Johnson’s remedy is clear. Smash the oligarchy. Nationalize the banks. Sell them off in medium-size pieces. Revise

antitrust laws so they can't get back together. Find ways to limit executive compensation. Permanently reduce the size and power of Wall Street.

The second and, to me, more persuasive theory revolves around ignorance and uncertainty. The primary problem is not the greed of a giant oligarchy. It's that overconfident bankers didn't know what they were doing. They thought they had these sophisticated tools to reduce risk. But when big events — like the rise of China — fundamentally altered the world economy, their tools were worse than useless.

Many writers have described elements of this intellectual hubris. Amar Bhidé has described the fallacy of diversification. Bankers thought that if they bundled slices of many assets into giant packages then they didn't have to perform due diligence on each one. In *Wired*, [Felix Salmon described](#) the false lure of the Gaussian copula function, the formula that gave finance whizzes the illusion that they could accurately calculate risks. Benoit Mandelbrot and Nassim Taleb have explained why extreme events are much more likely to disrupt financial markets than most bankers understood.

To me, the most interesting factor is the way instant communications lead to unconscious conformity. You'd think that with thousands of ideas flowing at light speed around the world, you'd get a diversity of viewpoints and expectations that would balance one another out. Instead, global communications seem to have led people in the financial subculture to adopt homogenous viewpoints. They made the same one-way bets at the same time.

Jerry Z. Muller wrote an indispensable version of the stupidity narrative [in an essay](#) called "Our Epistemological Depression" in *The American* magazine. What's new about this crisis, he writes, is the central role of "opacity and pseudo-objectivity." Banks got too big to manage. Instruments got too complex to understand. Too many people were good at math but ignorant of history.

The greed narrative leads to the conclusion that government should aggressively restructure the financial sector. The stupidity narrative is suspicious of that sort of radicalism. We'd just be trading the hubris of Wall Street for the hubris of Washington. The stupidity narrative suggests we should preserve the essential market structures, but make them more transparent, straightforward and comprehensible. Instead of rushing off to nationalize the banks, we should nurture and recapitalize what's left of functioning markets.



Both schools agree on one thing, however. Both believe that banks are too big. Both narratives suggest we should return to the day when banks were focused institutions — when savings banks, insurance companies, brokerages and investment banks lived separate lives.

We can agree on that reform. Still, one has to choose a guiding theory. To my mind, we didn't get into this crisis because inbred oligarchs grabbed power. We got into it because arrogant traders around the world were playing a high-stakes game they didn't understand.

# Recipe for Disaster: The Formula That Killed Wall Street

By Felix Salmon 02.23.09

In the mid-'80s, Wall Street turned to the quants—brainy financial engineers—to invent new ways to boost profits. Their methods for minting money worked brilliantly... until one of them devastated the global economy.

**A year ago**, it was hardly unthinkable that a math wizard like [David X. Li](#) might someday earn a Nobel Prize. After all, financial economists—even Wall Street quants—have received the Nobel in economics before, and Li's work on measuring risk has had more impact, more quickly, than previous Nobel Prize-winning contributions to the field. Today, though, as dazed bankers, politicians, regulators, and investors survey the wreckage of the biggest financial meltdown since the Great Depression, Li is probably thankful he still has a job in finance at all. Not that his achievement should be dismissed. He took a notoriously tough nut—determining correlation, or how seemingly disparate events are related—and cracked it wide open with a simple and elegant mathematical formula, one that would become ubiquitous in finance worldwide.

For five years, Li's formula, known as a [Gaussian copula function](#), looked like an unambiguously positive breakthrough, a piece of financial technology that allowed hugely complex risks to be modeled with more ease and accuracy than ever before. With his brilliant spark of mathematical legerdemain, Li made it possible for traders to sell vast quantities of new securities, expanding financial markets to unimaginable levels.

His method was adopted by everybody from bond investors and Wall Street banks to ratings agencies and regulators. And it became so deeply entrenched—and was making people so much money—that warnings about its limitations were largely ignored.

Then the model fell apart. Cracks started appearing early on, when financial markets began behaving in ways that users of Li's formula hadn't expected. The cracks became full-fledged canyons in 2008—when ruptures in the financial system's foundation swallowed up trillions of dollars and put the survival of the global banking system in serious peril.

David X. Li, it's safe to say, won't be getting that Nobel anytime soon. One result of the collapse has been the end of financial economics as something to be celebrated rather than feared. And Li's Gaussian copula formula will go down in history as instrumental in causing the unfathomable losses that brought the world financial system to its knees.

**How could one** formula pack such a devastating punch? The answer lies in the [bond market](#), the multitrillion-dollar system that allows pension funds, insurance companies, and hedge funds to lend trillions of dollars to companies, countries, and home buyers.

A bond, of course, is just an IOU, a promise to pay back money with interest by certain dates. If a company—say, IBM—borrows money by issuing a bond, investors will look very closely over its accounts to make sure it has the wherewithal to repay them. The higher the perceived risk—and there's always *some* risk—the higher the interest rate the bond must carry.

Bond investors are very comfortable with the concept of probability. If there's a 1 percent chance of default but they get an extra two percentage points in interest, they're ahead of the game overall—like a casino, which is happy to lose big sums every so often in return for profits most of the time.

Bond investors also invest in pools of hundreds or even thousands of mortgages. The potential sums involved are staggering: Americans now owe more than \$11 trillion on their homes. But mortgage pools are messier than most bonds. There's no guaranteed interest rate, since the amount of money homeowners collectively pay back every month is a function of how many have refinanced and how many have defaulted. There's certainly no fixed maturity date:

Money shows up in irregular chunks as people pay down their mortgages at unpredictable times—for instance, when they decide to sell their house. And most problematic, there's no easy way to assign a single probability to the chance of default.

Wall Street solved many of these problems through a process called tranching, which divides a pool and allows for the creation of safe bonds with a risk-free triple-A credit rating.

Investors in the first tranche, or slice, are first in line to be paid off. Those next in line might get only a double-A credit rating on their tranche of bonds but will be able to charge a higher interest rate for bearing the slightly higher chance of default. And so on.

The reason that ratings agencies and investors felt so safe with the triple-A tranches was that they believed there was no way hundreds of homeowners would all default on their loans at the same time. One person might lose his job, another might fall ill. But those are individual calamities that don't affect the mortgage pool much as a whole: Everybody else is still making their payments on time.

But not all calamities are individual, and tranching still hadn't solved all the problems of mortgage-pool risk. Some things, like falling house prices, affect a large number of people at once. If home values in your neighborhood decline and you lose some of your equity, there's a good chance your neighbors will lose theirs as well. If, as a result, you default on your mortgage, there's a higher probability they will default, too. That's called correlation—the degree to which one variable moves in line with another—and measuring it is an important part of determining how risky mortgage bonds are.

Investors *like* risk, as long as they can price it. What they hate is uncertainty—not knowing how big the risk is. As a result, bond investors and mortgage lenders desperately want to be able to measure, model, and price correlation. Before quantitative models came along, the only time investors were comfortable putting their money in mortgage pools was when there was no risk whatsoever—in other words, when the bonds were guaranteed implicitly by the federal government through Fannie Mae or Freddie Mac.

Yet during the '90s, as global markets expanded, there were trillions of new dollars waiting to be put to use lending to borrowers around the world—not just mortgage seekers but also corporations and car buyers and anybody running a balance on their credit card—if only investors could put a number on the correlations between them. The problem is excruciatingly hard, especially when you're talking about thousands of moving parts. Whoever solved it would earn the eternal gratitude of Wall Street and quite possibly the attention of the Nobel committee as well.

To understand the mathematics of correlation better, consider something simple, like a kid in an elementary school: Let's call her Alice. The probability that her parents will get divorced this year is about 5 percent, the risk of her getting head lice is about 5 percent, the chance of her seeing a teacher slip on a banana peel is about 5 percent, and the likelihood of her winning the class spelling bee is about 5 percent. If investors were trading securities based on the chances of those things happening only to Alice, they would all trade at more or less the same price.

But something important happens when we start looking at two kids rather than one—not just Alice but also the girl she sits next to, Britney. If Britney's parents get divorced, what are the chances that Alice's parents will get divorced, too? Still about 5 percent: The correlation there is close to zero. But if Britney gets head lice, the chance that Alice will get head lice is much higher, about 50 percent—which means the correlation is probably up in the 0.5 range. If Britney sees a teacher slip on a banana peel, what is the chance that Alice will see it, too? Very high indeed, since they sit next to each other: It could be as much as 95 percent, which means the correlation is close to 1. And if Britney wins the class spelling bee, the chance of Alice winning it is zero, which means the correlation is negative: -1.

If investors were trading securities based on the chances of these things happening to both Alice *and* Britney, the prices would be all over the place, because the correlations vary so much.

But it's a very inexact science. Just measuring those initial 5 percent probabilities involves collecting lots of disparate data points and subjecting them to all manner of statistical and error analysis. Trying to assess the conditional probabilities—the chance that Alice will get head lice *if* Britney gets head lice—is an order of magnitude harder, since those data points are much rarer. As a result of the scarcity of historical data, the errors there are likely to be much greater.

In the world of mortgages, it's harder still. What is the chance that any given home will decline in value? You can look at the past history of housing prices to give you an idea, but surely the nation's macroeconomic situation also plays an important role. And what is the chance that if a home in one state falls in value, a similar home in another state will fall in value as well?

$$\Pr[T_A < 1, T_B < 1] = \Phi_2(\Phi^{-1}(F_A(1)), \Phi^{-1}(F_B(1)), \gamma)$$

**Here's what killed your 401(k)** *David X. Li's Gaussian copula function as first published in 2000. Investors exploited it as a quick—and fatally flawed—way to assess risk. A shorter version appears on this month's cover of Wired.*

### Probability

Specifically, this is a joint default probability—the likelihood that any two members of the pool (A and B) will both default. It's what investors are looking for, and the rest of the formula provides the answer.

### Copula

This couples (hence the Latin term copula) the individual probabilities associated with A and B to come up with a single number. Errors here massively increase the risk of the whole equation blowing up.

### Survival times

The amount of time between now and when A and B can be expected to default. Li took the idea from a concept in actuarial science that charts what happens to someone's life expectancy when their spouse dies.

### Distribution functions

The probabilities of how long A and B are likely to survive. Since these are not certainties, they can be dangerous: Small miscalculations may leave you facing much more risk than the formula indicates.

### Equality

A dangerously precise concept, since it leaves no room for error. Clean equations help both quants and their managers forget that the real world contains a surprising amount of uncertainty, fuzziness, and precariousness.

### Gamma

The all-powerful correlation parameter, which reduces correlation to a single constant—something that should be highly improbable, if not impossible. This is the magic number that made Li's copula function irresistible.

**Enter Li, a star** mathematician who grew up in rural China in the 1960s. He excelled in school and eventually got a master's degree in economics from Nankai University before leaving the country to get an MBA from Laval University in Quebec. That was followed by two more degrees: a master's in actuarial science and a PhD in statistics, both from Ontario's University of Waterloo. In 1997 he landed at Canadian Imperial Bank of Commerce, where his financial career began in earnest; he later moved to Barclays Capital and by 2004 was charged with rebuilding its quantitative analytics team.

Li's trajectory is typical of the quant era, which began in the mid-1980s. Academia could never compete with the enormous salaries that banks and hedge funds were offering. At the same time, legions of math and physics PhDs were required to create, price, and arbitrage Wall Street's ever more complex investment structures.

In 2000, while working at JPMorgan Chase, Li published a paper in *The Journal of Fixed Income* titled "On Default Correlation: A Copula Function Approach." (In statistics, a copula is used to couple the behavior of two or more variables.) Using some relatively simple math—by Wall Street standards, anyway—Li came up with an ingenious way to model default correlation without even looking at historical default data. Instead, he used market data about the prices of instruments known as credit default swaps.

If you're an investor, you have a choice these days: You can either lend directly to borrowers or sell investors credit default swaps, insurance against those same borrowers defaulting. Either way, you get a regular income stream—interest payments or insurance payments—and either way, if the borrower defaults, you lose a lot of money. The returns on both strategies are nearly identical, but because an unlimited number of credit default swaps can be sold against each borrower, the supply of swaps isn't constrained the way the supply of bonds is, so the CDS market managed to grow extremely rapidly. Though credit default swaps were relatively new when Li's paper came out, they soon became a bigger and more liquid market than the bonds on which they were based.

When the price of a credit default swap goes up, that indicates that default risk has risen. Li's breakthrough was that instead of waiting to assemble enough historical data about actual defaults, which are rare in the real world, he used historical prices from the CDS market. It's hard to build a historical model to predict Alice's or Britney's behavior, but anybody could see whether the price of credit default swaps on Britney tended to move in the same direction as that on Alice. If it did, then there was a strong correlation between Alice's and Britney's default risks, as priced by the market. Li wrote a model that used price rather than real-world default data as a shortcut (making an implicit assumption that financial markets in general, and CDS markets in particular, can price default risk correctly).

It was a brilliant simplification of an intractable problem. And Li didn't just radically dumb down the difficulty of working out correlations; he decided not to even bother trying to map and calculate all the nearly infinite relationships between the various loans that made up a pool. What happens when the number of pool members increases or when you mix negative correlations with positive ones? Never mind all that, he said. The only thing that matters is the final correlation number—one clean, simple, all-sufficient figure that sums up everything.

The effect on the securitization market was electric. Armed with Li's formula, Wall Street's quants saw a new world of possibilities. And the first thing they did was start creating a huge number of brand-new triple-A securities. Using Li's copula approach meant that ratings agencies like Moody's—or anybody wanting to model the risk of a tranche—no longer needed to puzzle over the underlying securities. All they needed was that correlation number, and out would come a rating telling them how safe or risky the tranche was.

As a result, just about anything could be bundled and turned into a triple-A bond—corporate bonds, bank loans, mortgage-backed securities, whatever you liked. The consequent pools were often known as collateralized debt obligations, or CDOs. You could tranche that pool and create a triple-A security even if none of the components were themselves triple-A. You could even take lower-rated tranches of *other* CDOs, put them in a pool, and tranche them—an instrument known as a CDO-squared, which at that point was so far removed from any actual underlying bond or loan or mortgage that no one really had a clue what it included. But it didn't matter. All you needed was Li's copula function.

The CDS and CDO markets grew together, feeding on each other. At the end of 2001, there was \$920 billion in credit default swaps outstanding. By the end of 2007, that number had skyrocketed to more than \$62 *trillion*. The CDO market, which stood at \$275 billion in 2000, grew to \$4.7 trillion by 2006.

At the heart of it all was Li's formula. When you talk to market participants, they use words like *beautiful*, *simple*, and, most commonly, *tractable*. It could be applied anywhere, for anything, and was quickly adopted not only by banks packaging new bonds but also by traders and hedge funds dreaming up complex trades between those bonds.

"The corporate CDO world relied almost exclusively on this copula-based correlation model," says [Darrell Duffie](#), a Stanford University finance professor who served on Moody's Academic Advisory Research Committee. The Gaussian copula soon became such a universally accepted part of the world's financial vocabulary that brokers started quoting prices for bond tranches based on their correlations. "Correlation trading has spread through the psyche of the financial markets like a highly infectious thought virus," [wrote](#) derivatives guru [Janet Tavakoli](#) in 2006.

**The damage was foreseeable** and, in fact, foreseen. In 1998, before Li had even invented his copula function, [Paul Wilmott](#) wrote that "the correlations between financial quantities are notoriously unstable." Wilmott, a quantitative-finance consultant and lecturer, argued that no theory should be built on such unpredictable parameters. And he wasn't alone. During the boom years, everybody could reel off reasons why the Gaussian copula function wasn't perfect. Li's approach made no allowance for unpredictability: It assumed that correlation was a constant rather than something mercurial. Investment banks would regularly phone Stanford's Duffie and ask him to come in and talk to them about exactly what Li's copula was. Every time, he would warn them that it was not suitable for use in risk management or valuation.

In hindsight, ignoring those warnings looks foolhardy. But at the time, it was easy. Banks dismissed them, partly because the managers empowered to apply the brakes didn't understand the arguments between various arms of the quant universe. Besides, they were making too much money to stop.

In finance, you can never reduce risk outright; you can only try to set up a market in which people who don't want risk sell it to those who do. But in the CDO market, people used the Gaussian copula model to convince themselves they didn't have any risk at all, when in fact they just didn't have any risk 99 percent of the time. The other 1 percent of the time they blew up. Those explosions may have been rare, but they could destroy all previous gains, and then some.

Li's copula function was used to price hundreds of billions of dollars' worth of CDOs filled with mortgages. And because the copula function used CDS prices to calculate correlation, it was forced to confine itself to looking at the period of time when those credit default swaps had been in existence: less than a decade, a period when house prices soared. Naturally, default correlations were very low in those years. But when the mortgage boom ended abruptly and home values started falling across the country, correlations soared.

Bankers securitizing mortgages knew that their models were highly sensitive to house-price appreciation. If it ever turned negative on a national scale, a lot of bonds that had been rated triple-A, or risk-free, by copula-powered computer models would blow up. But no one was willing to stop the creation of CDOs, and the big investment banks happily kept on building more, drawing their correlation data from a period when real estate only went up.

"Everyone was pinning their hopes on house prices continuing to rise," says [Kai Gilkes](#) of the credit research firm CreditSights, who spent 10 years working at ratings agencies. "When they stopped rising, pretty much everyone was caught on the wrong side, because the sensitivity to house prices was huge. And there was just no getting around it. Why didn't rating agencies build in some cushion for this sensitivity to a house-price-depreciation scenario? Because if they had, they would have never rated a single mortgage-backed CDO."

Bankers should have noted that very small changes in their underlying assumptions could result in very large changes in the correlation number. They also should have noticed that the results they were seeing were much less volatile than they should have been—which implied that the risk was being moved elsewhere. Where had the risk gone?

They didn't know, or didn't ask. One reason was that the outputs came from "black box" computer models and were hard to subject to a commonsense smell test. Another was that the quants, who should have been more aware of the copula's weaknesses, weren't the ones making the big asset-allocation decisions. Their managers, who made the actual calls, lacked the math skills to understand what the models were doing or how they worked. They could, however, understand something as simple as a single correlation number. That was the problem.

"The relationship between two assets can never be captured by a single scalar quantity," Wilmott says. For instance, consider the share prices of two sneaker manufacturers: When the market for sneakers is growing, both companies do well and the correlation between them is high. But when one company gets a lot of celebrity endorsements and starts stealing market share from the other, the stock prices diverge and the correlation between them turns negative. And when the nation morphs into a land of flip-flop-wearing couch potatoes, both companies decline and the correlation becomes positive again. It's impossible to sum up such a history in one correlation number, but CDOs were invariably sold on the premise that correlation was more of a constant than a variable.

No one knew all of this better than David X. Li: "Very few people understand the essence of the model," he told *The Wall Street Journal* way back in fall 2005.

"Li can't be blamed," says Gilkes of CreditSights. After all, he just invented the model. Instead, we should blame the bankers who misinterpreted it. And even then, the real danger was created not because any given trader adopted it but because every trader did. In financial markets, everybody doing the same thing is the classic recipe for a bubble and inevitable bust.

Nassim Nicholas Taleb, hedge fund manager and author of *The Black Swan*, is particularly harsh when it comes to the copula. "People got very excited about the Gaussian copula because of its mathematical elegance, but the thing never worked," he says. "Co-association between securities is not measurable using correlation," because past history can never prepare you for that one day when everything goes south. "Anything that relies on correlation is charlatanism."

Li has been notably absent from the current debate over the causes of the crash. In fact, he is no longer even in the US. Last year, he moved to Beijing to head up the risk-management department of China International Capital Corporation. In a recent conversation, he seemed reluctant to discuss his paper and said he couldn't talk without permission from the PR department. In response to a subsequent request, CICC's press office sent an email saying that Li was no longer doing the kind of work he did in his previous job and, therefore, would not be speaking to the media.

In the world of finance, too many quants see only the numbers before them and forget about the concrete reality the figures are supposed to represent. They think they can model just a few years' worth of data and come up with probabilities for things that may happen only once every 10,000 years. Then people invest on the basis of those probabilities, without stopping to wonder whether the numbers make any sense at all.

As Li himself said of his own model: "The most dangerous part is when people believe everything coming out of it."

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