



**DIRECTORATE GENERAL FOR INTERNAL POLICIES**  
**POLICY DEPARTMENT A: ECONOMIC AND SCIENTIFIC POLICIES**

**ECONOMIC AND MONETARY AFFAIRS**

# **Defining and Measuring Systemic Risk**

## **NOTE**

### **Abstract**

This note examines the possibility of measuring systemic risk at the European and global level. It makes the following arguments:

1. Systemic risk mostly arises as contagion from an individual bank failures. Systemic risk measurement implies assessing individual bank risk and then detecting contagion risk.
2. Risk measurement at the bank level has failed because it rested on assumptions that are adequate in quiet times but incompatible with a crisis situation. It is very unlikely that we will be able in the foreseeable future to build reliable measurement instruments at the individual institution level. This applies *a fortiori* to the measurement of systemic risk since contagion risk is poorly understood and involves the processing of massive information.
3. Meanwhile, there is no other solution than to collect and process as best as possible information about individual institutions. At the euro area level, the ECB is where this can and should be done.

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## **AUTHOR**

Prof. Charles Wyplosz  
Graduate Institute of International and Development Studies, Geneva.

## **RESPONSIBLE ADMINISTRATOR**

Arttu MAKIPAA  
Policy Department Economic and Scientific Policies  
European Parliament  
B-1047 Brussels  
E-mail: [arttu.makipaa@europarl.europa.eu](mailto:arttu.makipaa@europarl.europa.eu)

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To contact the Policy Department or to subscribe to its monthly newsletter please write to:  
[poldep-esc@europarl.europa.eu](mailto:poldep-esc@europarl.europa.eu)

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## EXECUTIVE SUMMARY

A central lesson from the crisis is how poorly finance theory deals with the possible occurrence of crises. Facts that did not match theory were called “anomalies” and the crisis itself has become a massive anomaly. This observation carries immense practical implications for two main reasons:

1. Most of the instruments used to price and identify risk are based on principles that fail to account for the recurrent emergence of financial crises.
2. Efforts at developing warning indicators and at measuring systemic risk will be frustrated by the current lack of knowledge.

Systemic risk captures either the possibility that a large shock from outside seriously impairs the financial sector or the possibility that the failure of a particular financial institution spreads to other, possibly most other financial institutions. Systemic risk is important because a sudden loss of effectiveness of the financial sector seriously affects the real economy.

Assessing the first source of systemic risk – a large outside shock – involves the identification of macroeconomic vulnerabilities. This is often possible but translating such identification in practical warning indicators is fraught with difficulties. The reason is that vulnerabilities, even large ones, do not necessarily translate into crises. With good luck, no crisis occurs even though the risk is large; with bad luck, relatively small vulnerabilities result in massive crises. This may seem as of little consequence: why not just assess and reveal vulnerabilities? The problem is that revealing vulnerabilities may be enough to trigger a crisis. This is why a previous effort at developing early warning indicators, carried out by the IMF after the Asian crisis, has been mostly disappointing. There is no reason to believe that a renewed effort will be any less disappointing.

Assessing the second type of risk, the transmission from individual financial institutions to the whole financial system, is even more difficult. It should start with identifying risk of individual banks and financial institutions. But we are currently poorly equipped to do so. Then we need to assess the possibility of contagion. This is mission impossible, at least at this stage. The degree of interconnectedness of individual banks and financial institutions is extraordinarily large. It may be possible to try and document the situation – a massive effort in its own right – but we are even less well equipped to process this information to reach reliable practical conclusion. This may be possible one day, but not in the foreseeable future.

The implication is that, while research progresses on all these fronts, we should focus on making our banking and financial systems safer by reducing risk in individual banks and financial institutions. This means simpler and more encompassing capital and liquidity requirements. Banks and financial institutions mostly oppose these measures because a robust result from finance theory is that risks and profitability go hand in hand.

Europe faces the added difficulty that bank supervision is carried out at the national level while macro risk is increasingly present at the euro area level. The ECB is the only existing institution able to can collect information about individual banks and financial institutions and try to assess the resulting systemic risk. The situation is similar at the global level. The Basel Committee on Banking Supervision and the newly created Financial Stability Board can perform the same task at the global level, but they are even less likely than the ECB to receive the necessary information on individual banks and financial institutions.

## **1. KEY LESSONS FROM THE CRISIS**

The crisis has made it clear that our theories of finance may be useful in normal times but are wholly inadequate at times of stress. The gap between the sophistication of finance theory and its adequation to the actual workings of markets has also been found much wider than hitherto believed.

### **1.1. A very brief presentation of finance theory**

Modern finance theory is used to “price financial instruments”, i.e. to provide a simple characterisation of highly complex products. These products have emerged over the last two decades because of deregulation but also because finance specialists have become able to formally describe their properties. Options and derivatives had been known for a long time but their practical use had remained very limited precisely because it was then impossible to understand their intricate properties and therefore to reliably put a price tag on them. The amazing progress of finance theory, supported by the data-processing power of ever more powerful computers, has broken down this limit and heralded the new world that ran into deep trouble in 2007.

Finance is about uncertainty. All financial products – or assets - can be described as a promise to pay some amount in the future. The amount may be spread over the life – or maturity – of the product, or it may depend on some events that may or may not materialize. The common feature of every asset is that it only concerns the future and a trivial characteristic of the future is that it is uncertain. It follows that any asset is inherently risky. The risk may be very low, as with bonds issued by respectable governments, or it may huge, as with “junk bonds” issued by firms with a fair chance of becoming bankrupt, but it is always there.

Finance theory must therefore describe risk, and it does. It imagines a large, possibly infinite, number of “shocks”, i.e. unpredictable events that may or may not happen. To be operational, however, finance theory cannot be fully agnostic about these shocks. It makes assumptions about their frequency and size and, importantly, about whether the various shocks tend to appear together – in which case they are said to be correlated – or not – in which case they are said to be independent. The quasi totality of finance theory assumes that these shocks are “normal” and independent. Normal means that they are distributed along a bell shape as shown below. The height of the curve represents the probability of a given value to be observed, so the bell shape says that most of the time we will values in the middle of the range. Very few will occur at the far right or the far left; this is captured by saying the tails are thin. The normal distribution is used because it seems reasonable, but mostly it is relatively easily tractable. Indeed, assuming that the shocks are normal and independent allows theorists to compute the “normal” price of almost any asset, no matter how complex it is, i.e. how many conditions are attached to its payoff.

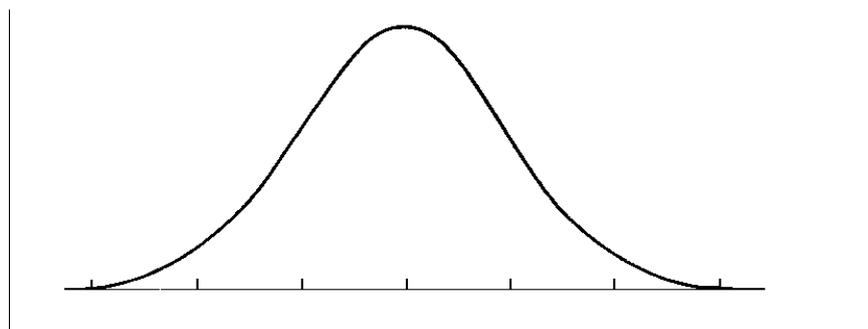


Figure 1. The Bell-Shaped Normal Distribution

## 1.2. Anomalies

Decades of research have led to the discovery of “anomalies”, meaning shocks that do not fit well the bell shape. For example, it has been known that the tails are usually fatter meaning that extreme events are more likely than commonly assumed. Note that finance specialists call anomalies the facts that do not match their assumptions rather than accepting that facts are facts and, therefore, that it is their assumptions that are anomalous. Herein lies the fundamental weakness of finance theory.

Good finance theorists are well aware of the limits of their constructions and some research has tried to move away from the normal distribution, but it is very difficult. Most practitioners, however, learn and forget the anomalies. They come to regard the complex mathematical models that are created by the theorists as black boxes. They price assets using software that they do not really understand. Importantly, they lose track of the possibility that the prices are wrong. More worrisome, perhaps, is that most top-level finance managers have little or no understanding of advanced finance theory. Consequently, they cannot even ask their employees the questions that would illuminate the limits of the instruments that they use.

## 1.3. A burst of anomalies

The crisis can be seen as a burst of anomalies. It started in the US housing markets where prices were not expected to decline. It went on to the famous Asset Backed Securities, complex mixtures of mortgages that assumed that the shocks were normal and independent. In the event most the shocks occurred at the low end (there were very few good surprises) and they occurred at the same time (they were highly correlated, not independent at all). Assets whose total value was in the hundreds of billions of dollars were simply fatally mispriced. They were so mispriced that nobody could remotely imagine their values, so they stopped being traded. They became known as toxic assets because no one would want to touch them. The Box goes into more details.

### Financial meltdown

The crisis was triggered by the (in)famous subprime mortgage loans. These loans started with very low interest rates, which were scheduled to rise steeply after two years. The idea was that borrowers would renegotiate contracts at that point and could borrow more at low rates because housing prices would have increased, raising the value of their collateral. The whole construction assumed that house prices always rise and never decline. In addition to being wholly unrealistic, this assumption did not fit into a bell curve! Nevertheless,

mortgage lenders sold their loans to banks that bunched large number of them into instruments – called asset-backed securities – that were further reassembled in other instruments (CDOs, etc.) and priced according to the formulae based on the assumptions discussed earlier. Credit rating agencies spun their own models, which are the same, and reassured investors around the world – chiefly banks it turned out – bought into the schemes.

Market enthusiasts raved about global diversification. The large risks of lending to NINJA (No Income, No Job) US home buyers had been moved around the world, each single loan being a trivially small part of large packages collecting hundreds of loans. Diversification was achieved since each borrower's ability to serve his mortgage loan was assumed to be unrelated to his neighbours own abilities. This is the standard assumption that shocks – here defaults by individual borrowers – occur randomly and independently. But when all house prices started to decline back from the unbelievable heights that they had reached, the shocks turned out to be not random but systematic, and highly correlated. Oops, diversification had turned into contagion.

Then, the rest of finance theory turned out to be prophetic, including the violence of the ensuing events, which came as a surprise to hapless investors who should have known better. Banks loaded with these now-toxic assets suffered losses of unknown proportions. They had the choice of either sell them at whatever price they could and pocket losses, or keep them on their books and recognize the losses according to fair pricing accounting rules. They mostly chose to not sell and to not recognize the losses. As a result it was impossible to know how seriously affected was each major bank. Suspicion spread among banks at lightning speed and soon no bank would lend anything to another bank. The same banks that had indirectly offered loans to NINJA borrowers for years, now would not lend a penny to the most highly reputed financial institutions. The interbank market seized up and the global financial system came to a halt.

#### **1.4. Lessons**

The first sad lesson is that theories developed on the basis of fair weather assumptions cannot work at crisis times. Worse, they cannot predict crises and yet financial crises are fundamentally unavoidable. The reason why they are unavoidable is that every instrument is risky, as previously noted, that risk means that good and bad things can happen at the tails, that what can happen will happen eventually, and that the tails are fatter than commonly assumed. This means that finance theory must go back to its basics.

The next lesson follows. We do not have adequate pricing procedures for complicated assets. Those who work with such assets must realize that they cannot evaluate the risk that they take. Sophisticated risk-management procedures such as Value at Risk (V@R), which have become the industry standard, are potentially flawed and therefore unreliable.

The inescapable conclusion is that we now know that we cannot measure with any degree of precision the riskiness of most assets and therefore the riskiness of the financial institutions that hold these assets. During quiet periods, existing theories and risk estimates may operate as acceptable precision. Periods of market quiescence

overwhelmingly dominate periods of market instability, so we may think that we have a reasonable measure of asset riskiness. This is deeply misleading.<sup>1</sup>

## 2. WHAT IS SYSTEMIC RISK?

There is no simple uncontroversial definition of systemic risk. In general terms, systemic risk refers to events that result in the impairment of financial markets that prevent them from fulfilling their functions. Systemic risk occurs when bank credit is curtailed or when asset market prices undergo a sharp decline. In both cases, the real economy is likely to be hit as well.

Systemic risk differs from the individual risk of individual financial institutions. These firms may individually face serious stress without it being generalized to other firms. Thus systemic risk occurs either when the whole banking or financial system is hit by a large external shock or when there is contagion. Most often, contagion is the usual channel, which is why systemic risk detection involves alertness about links among banks and financial institutions.

Intuitively, we can think of financial markets as a chain whose solidity depends on the weakest link. Identifying these weak links is the aim of systemic risk analysis. One would like to think that individual firms represent each of the links, but this is not always so. For example, the seizing up of the interbank market on August 8, 2007 was not caused by any particular institution but by mutual suspicion among tightly interconnected banks. Connectedness, therefore, is an element of risk, in addition to individual firm risk.

More generally, the chain is not a single line but a network, indeed like a net that makes up a hammock. A particular firm's weakness has systemic implications only if its failure is likely to directly or indirectly trigger the failures of other firms. Otherwise, the net has a hole but it can still support some weight.

An additional complexity comes from the fact that firms do not know the risk carried by other firms to which they are connected, directly or indirectly. It then becomes possible that one firm, which suspects trouble in another firm to which it may be indirectly connected, withdraws funds from a firm with which it is directly connected and thus precipitates that firm into serious hardship.<sup>2</sup>

## 3. CAN SYSTEMIC RISK BE MEASURED?

We have measures of systemic stress (spreads like those between LIBOR and OIS rates, explicit indices designed by the Federal Reserve of Kansas City and by the IMF), but those emerge after the facts. For reasons apparent in the previous Section, measuring systemic risk *ex ante* is likely to be a long and difficult enterprise, quite possibly mission impossible.

### 3.1. Macro risks

The easier risk to analyze concerns large shocks external to the financial system. A number of economists have long warned that the global imbalances (the combination of a large US

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<sup>1</sup> This observation is tightly linked to the often-made observation that banks took in the profits and had the losses socialized. If risk of the benign variety assumed by Finance Theory, it adequately captures asset performance in good times, when banks receive profits, and severely misses the losses at crisis time, from which are shelved when they are bailed out.

<sup>2</sup> This mechanism, which bears some resemblance to the events that led to the collapse of Lehman Brothers, is analyzed in a recent paper by Caballero and Simsek.

external deficit and a large Chinese surplus) were unsustainable and would only be solved by a financial crisis. In the event, there is little evidence that these imbalances actually triggered the current crisis.<sup>3</sup> Yet, such macroeconomic risks are usually well observed before they shake the financial systems. Over the last few years, collapses of financial systems in Russia (1998) and Argentina (2001) resulted from severe macroeconomic tensions that were well identified before the crises. Even though, macroeconomic risks are not always detected *ex ante*. The Asian crisis of 1997 came as a surprise when it started in Thailand and its contagion to many other East Asian countries was even more surprising. Following the Asian crisis, the IMF undertook a large effort to develop macroeconomic crisis indicators with highly disappointing results.

A renewed effort is now under way and it is likely to be as disappointing as the first one. The essential reason is that some crises are self-fulfilling: they happen when markets believe they will happen, but they do not *need* to happen. They are the consequence of some pre-existing vulnerabilities but these vulnerabilities are not serious enough to trigger a crisis with a 100% probability. One can detect vulnerabilities but this is enough to conclude that a crisis will follow. As a consequence, crisis warning indicators are delicate to use: one must balance the risk of not warning of a crisis that eventually occurs (Type I error) with the risk of warning of a crisis that will not occur (Type II error) or, worse, that can actually trigger a crisis that should not have occurred (self-fulfilling prophecy). This is pretty much like a gun trigger: it can be too tight and the gun does not go off, or it can be too loose and the gun fires indiscriminately.

### **3.2. Micro risks**

The current crisis started in a small segment of the loan market. Several economists had identified the house price bubble and the spread of subprime loans as a threat to the loan market. When the market turned around in late 2006 and strains developed in the loan market, very few observers expected what followed. Similarly, the crisis eventually brought a very large investment bank, Bear Stearns, to the verge of collapse but, when the bank was rescued, very few observers imagined what would follow. This is probably why the US Treasury refused to bail out Lehman Brothers. Yet, its collapse brought down the global financial system. Measuring systemic risk thus involves two steps: 1) Identify micro risks – a market, an institution; 2) Identify the risk of contagion to other markets and/or institutions. Each step is a formidable challenge. Given current knowledge, it is an impossible challenge.

The difficulty of identifying micro-risks has been abundantly illustrated during the current crisis. In spite of the sophisticated instruments developed as part of the Basel II Accord, most bank supervisors have not detected the vulnerabilities of the shadow banking system. Section 1.3 explains why the state of the art of finance theory is deficient in this respect. Then contagion comes from the myriad of interbank linkages that can transform a small shock into a complete meltdown. The main theme of Section 1 is that we currently poorly understand these linkages. It is also likely that bank supervisors find it difficult to track down interconnections, perhaps they would not know how to analyze this information.

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<sup>3</sup> The argument against this popular view is too long to develop here. Suffice to observe that housing price bubbles, arguably the visible trigger, developed in some countries but not in all countries. Why Spain and Ireland and not Germany and Switzerland, whose banks were deeply affected?

## 4. WHAT CAN AND WHAT CANNOT BE DONE?

### 4.1. Drawing the appropriate lessons

Policymakers are naturally calling for better instruments to detect systemic risk. They stand to be greatly disappointed with what they will get. Interested parties – banks and financial institutions, regulatory and supervisory agencies, developers of risk measurement instruments – are likely to argue that this pessimism is unjustified. The failure of self-regulation by banks as part of the Basel Accord is a direct consequence of the failure of the highly sophisticated instruments (internal models of banks, stress testing with V@R exercises) that were touted as unassailable. In the end, these instruments failed, but the Accord served well banks, regulators and model developers. It would be a tragic mistake to follow the same route again.

A more reasonable route is to accept our limitations and focus instead on making our banking and financial system safer. In other words, while still trying to better measure and detect systemic risk, we should put emphasis on trying to reduce it. This means simpler and more encompassing capital and liquidity requirements. This is what banks and financial institutions do not want to see, because a robust result from finance theory is that risks and profitability go hand in hand. The crisis is first and foremost due to excessive risk-taking by banks and financial institutions in search for higher profits. It would be a tragic mistake to give up on risk reduction measures.

### 4.2. One money, one financial system, one regulator and one supervisor

Even before the launch of the euro, it was pointed out that the common currency should come with a single central bank and a unified set of regulations implemented by a common supervisory system.<sup>4</sup> The main reason is that the common currency will only deliver all its benefits when it is supported by fully integrated banking and financial systems. The point has been officially accepted by the European Commission. Having observed how slowly financial integration proceeds, it has pioneered the Financial Services Action Plan. Yet it has shied away from advocating a single regulator and a common supervisory system. The reason is that many national governments wish to promote their own banks and financial institutions. As a consequence national regulators and supervisors face a conflict of interest: they are committed to impose and implement prudential norms to their banks and financial institutions but they are always concerned that these norms can undermine the competitiveness of the same firms. In addition, national regulators and supervisors are naturally concerned about their own powers, possibly even about their own existence.<sup>5</sup>

It was always anticipated that, some day, a crisis would expose the inadequate organization of regulation and supervision in the euro area. The collapses of Fortis Bank and of Dexia have confirmed those fears. This has prompted the creation of the de Larosière Commission. The Commission has not dealt in great detail with the nature of reforms in bank regulation and supervision, its efforts were mostly diplomatic: how to advance the case of unified regulation and supervision in front of string opposition from

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<sup>4</sup> The point was made in Begg et al (1998) but rejected by both the ECB and the European Commission as "politically impossible" and even dangerous. David Begg, Paul de Grauwe, Francesco Giavazzi, Harlad Uhlig and Charles Wyplosz, "The ECB: Safe at Any Speed?", *Monitoring the European Central Bank* 1, CEPR, November 1998.

<sup>5</sup> A similar situation exists in the US where, for historical reasons, a web of agencies compete to survive.

national regulators and supervisors. This issue is discussed in my previous briefing note, which argues that the ECB must play a central role because it is the sole institution which is independent from national interests and with adequate technical capabilities and because macro supervision is an integral part of its mission to promote financial market stability.<sup>6</sup> But this discussion about institutions leaves aside the question of the instruments to be developed and put in place.

The arguments developed in Section 3 imply that the ECB, as part of the European Systemic Risk Council (ESRC) should contribute to the research of indicators, without expecting rapid results. It should mainly pursue two objectives:

- Gain full access to information on large banks that may become the source of systemic risk – this is the “twin peak” approach of the de Larosière Commission Report. As the British example has shown during the Northern Rock crisis, it is enough for the ECB to be given information when a crisis is under way. The ECB must constantly know, and indeed be familiar with the exact situation of all systemically important institutions. Only then can it take prompt action at crisis time. In fact, this is also a condition for the ESRC to be able to carry out its preventive duty.

- Consolidate national level information. Since a growing number of banks operate across borders, and since it is likely that more banks will become multinational, national supervisors increasingly have a partial view of the institutions under their responsibility. Not only does this hamper microsupervision, it also makes macrosupervision impossible. Only a euro area-wide institution is in the position of trying to assess – with whatever precision it can – systemic risks.

### **4.3. Global regulation and supervision**

The problems faced within the euro area are similar to those that arise at the global level. The crisis has shown the extraordinary degree of interconnectedness of banks and financial institutions across the developed world and the implication of financial crisis in this part of the world for the global economy. The lesson is that it would be highly desirable to have a single global regulator and a single global supervisor. The European example shows that this is not going to be a realistic proposition for many years or decades to come. More modest arrangements are possible and, indeed, under way.

The Basel Committee on Banking Supervision – which is independent of the BIS where its secretariat is housed – has become the shadow world regulator. This is where common regulations are negotiated by national regulators and a whole array of professional bodies. It is up to national governments to implement the agreements. Its weaknesses are well known and two may be mentioned. First, it does not decide but suggests. The Basel II Accord of 2004 was implemented by the European Union in 2007, in a few other countries in 2008 but not yet fully in the US. Second, this is an ad hoc Committee with no formal legitimacy. Starting with 10 countries in 1974, it now includes 27 countries.

The Financial Stability Board (FSB), also housed in the BIS, was created by the G20 in 2009 in response to the crisis. It resembles at the global level the ESRC since its role is to propose regulations and to collect information on systemically important banks from national supervisors. Much like the ESRC it will be asked to develop instruments and it will have to struggle to obtain detailed information about individual banks and financial

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<sup>6</sup> Charles Wyplosz (2009), “What Role for the ECB in Financial Market Supervision”, European Parliament, September 2009.

institutions. At the present time, it has a rather small secretariat and cannot ambition to carry out global supervision in house, a responsibility that it does not have and that national governments are most unlikely to delegate.

This leaves the IMF with a limited role concerning global macrosupervision. One could argue that the IMF has a large and highly competent staff, which the FSB does not have, which could allow for effective supervision. However, this would require access to detailed information about individual banks and financial institutions, which national supervisors will not want to provide. Lacking such information, the IMF and the FSB are unlikely to make much progress toward risk measurement and assessment. Meanwhile the IMF and the FSB have started to work closely together in developing new ideas in response to the crisis.