On the Feasibility of Risk Based Regulation*

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Abstract

Risk based regulation has emerged as the primary ingredient in the Basel–II proposals, where a bank capital is to become a direct function of a bank's riskiness. While the notion that bank capital be risk sensitive is intuitively appealing, the actual implementation, in the form of Basel–II, carries with it a host of potentially perverse side effects. Basel–II may increase financial risk, both for individual institutions and the entire banking system, and hence promote financial instability. This can happen, e.g., due to the endogenous nature of risk.

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1 Introduction

Over time, financial regulation has evolved considerably, from lending of last resort[1] approach to deposit insurance and activity restrictions.[2] The latest fashion in banking regulation is *risk based regulation* which is a system whereby a bank's minimum capital is determined by a sophisticated risk model, operated within the bank, and audited by the supervisors. This idea is at the heart of the Basel–II Proposals. It is beyond the scope of this paper to discuss the rationale for banking regulation in general. The history of bank failures and their economic cost suggests that some form of regulation is inevitable. My interest here is to explore the twilight zone of Basel–II, in particular the financial economic context of the Proposals, their scope for effectiveness and any potential side effects.

Banking regulations have traditionally been designed and implemented on a local or national level. The fall of Bankhaus Herstatt in 1974 and Banco Ambrosiano in 1982, however, served as a reminder that banking is an international business, where international coordination is necessary for supervision to be effective. The absence of international cooperation can amplify the impact of individual failures, as it did in the Herstatt case. Herstatt and Ambrosiano prompted new thinking in banking regulation, with the Basel Committee (BC) on Banking Supervision given the role of formulating capital adequacy rules, culminating in the 1988 Capital Accord, setting minimum capital at 8%. A key feature of the 1988 Accord is that capital is *risk weighted*, a feature which has remained an integral part of subsequent regulatory proposals. In 1996, the Basel Committee proposed an amendment to the original Accord suggesting the use of internal models for the measurement of market risk. The perceived success of the 1996 Amendment, and the rather visible flaws in the original Accord have motivated the Basel Committee to apply the methodology of risk based regulation to operational and credit risk, with liquidity risk perhaps to follow.

Risk based regulation is based on the premise that the regulatory treatment of

[1]Lending of last resort (LOLR) was proposed by Bagehot (1873) and first used in the rescue of Barings in 1890. LOLR depends on the central bank providing liquidity to financial institutions in crisis. As a such, it can be very effective in preventing the spread of contagion if used properly. Of course, LOLR inevitably implies moral hazard as well.

[2] Deposit insurance was set up to prevent crisis by reinforcing public confidence in the banking system. Deposit insurance however carries with it its own baggage of problems, and its dual use for consumer protection has proved to be especially problematic. Activity restrictions refers to regulators deciding what activities financial institutions can be engaged in. Along the way banking regulations have added e.g. solvency requirements, minimum capital, and supervision.

individual banks reflects their riskiness, e.g., so that more risky banks have to carry a higher capital charge and perhaps be subject to closer scrutiny by regulators. The objective of these regulations is more macroprudential than microprudential in the terminology of Crockett (2000). In specific implementations the supervisors require financial institutions to measure and aggregate their risks and report some of this risk to the authorities and the financial community. Basel–II suggests a particular interpretation of risk based regulation by means of its three pillars; *minimum capital requirements*, the *supervisory review process*, and *market discipline*. Within this system, banks do have some leeway in how risk sensitive their regulatory treatment is, with smaller banks perhaps opting for the more standardized models in measuring risk, with the larger (and more relevant) banks opting for the internal models approach, where banks design their own (supervisory approved) risk models.

On the face of it, the concept of risk based regulation is very appealing. Some banks have successfully applied sophisticated risk models in their internal operations, and much would be gained if others did the same. After all, bank failures are costly, and impose significant externalities on the economy (see e.g. Honohan and Klingebiel, 2002), and in many cases are contagious, as a single institutional failure triggers a domino effects in bank failures.

But beauty is only skin deep, and the Basel–II Proposals have perhaps received more criticism than the Basel Committee and other proponents expected.[3] Most of the criticism of Basel–II originates from lobbying by individual banks and other special–interest groups. However, the Proposals have received more fundamental criticism, expressed both in the official comments as well as subsequent papers. This criticism ranges from doubts about the statistical models advocated in Basel–II, to financial economic analysis of the implications of Basel–II. In this paper I focus on two criticisms of Basel–II:

- **A Procyclicality:** The potential for procyclicality is downplayed, both in the actual Proposals as well as public statements by supervisors. Recent financial economic research suggests that the possibility of vicious feedback loops between prices, volatility, and liquidity is considerable in times of crisis, and that the current Basel–II may actually amplify these vicious feedback loops.

- **B Statistical Measurement of Risk:** The Proposals place considerable faith in the ability of statistical models to accurately measure risk. ("Banks are pretty well able to price credit risk" Crockett, 2003). How-

[3]Witness the official comments "The New Basel Capital Accord: Comments received on the Second Consultative Package", currently at `www.bis.org/bcbs/cacomments.htm`.

ever, recent methodological advancements, e.g., coherent risk measures and nonlinear dependence, cast considerable doubt on the accuracy of measured risk.

While the proponents of Basel–II sometimes acknowledged some of these criticisms, the common rejoinder is that banks are too important to be left unregulated and that Basel–II is the best regulatory mechanism on offer. I think such comments are shortsighted. A criticisms of Basel–II does not imply that banks should not be regulated, indeed, banking regulations probably inevitable, it is important to make sure it is effective without imposing too many burdens on the institutions themselves. This is the test that Basel–II fails. The financial system is a complex organism, comprising of a large number of individuals making decisions. This implies that the financial system, especially in the aggregate, is not easily amiable to be described by a set of engineering equations describing risk. Such modelling of risk is much akin to the old-style Macro models where the entire economy was described by a relatively small number of equations. As demonstrated by *rational expectations*, a key flaw in the old-style macro models is that they are not invariant under observation. The same flaw applies to traditional risk models, implying that risk is endogenous.

An effective regulatory mechanism needs to take into account the possibility of procyclicality and incorporate recent advancements in the statistical modelling of risk. As the quotes below demonstrate, key banking supervisors dismiss such criticism, but it is revealing that the propensity for procyclicality is rejected out of hand without any evidence. Hence, the basic criticism stands. It would be much better if the Basel Committee acknowledged that the world is more complex than assumed by Basel–II, and incorporate risk endogeneity and non-linear dependence into the Capital Accords.

2 On the Nature of Financial Risk and Decision Making

Suppose before leaving your house you note that the weather forecast reports a high probability of rain, and as a consequence you carry an umbrella. You are therefore hedging against rain. Perhaps other people make the same observation and also carry the rain hedge. In spite of this, the probability of rain does not change; the probability of rain is *exogenous* to the decision–making process.

Alternatively, suppose that after checking the financial news in the morning you reach the conclusion that risk in the markets has increased which in turn prompts you to hedge against this risk. In doing so you have an infinitesimal effect on the statistical properties of market prices. If somebody else reaches the opposite conclusion, i.e., that risk is decreasing, perhaps the effects of both of your trading strategies cancel each other out. If however this person agrees with you, then the impact on the statistical properties of market prices is even higher. If a significant number of people reach the same conclusion, the impact on market prices could be substantial. In other words, in contrast to the weather, market prices are *endogenous* to the decision–making process, implying that hedging and risk based regulations have the potential to be procyclical.

Recent research has studied the heterogeneity in bank behavior, addressing such issues as the impact of risk constraints and risk regulations on the statistical properties of market prices. The focus of this research is not on average or typical market conditions but instead on financial crisis. Two such research agendas are the global games model of Morris and Shin (1998, 1999) and the constrained general equilibrium model of Daníelsson and Zigrand (2003).

2.1 Global Games and Endogenous Prices

The idea that investors not only react to economic fundamentals dates back to the very beginning of modern economic analysis. An interesting take on this is provided by Keynes (1936, General Theory p. 156):

> "professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole"

Morris and Shin (1998, 1999)[4] (MS) formalize this idea where they surmise that economic agents do not play *a game against nature* but instead a game

[4]Heinemann (2000) shows was that when there is large noise, the exact distribution of the noise is important for the equilibrium outcome. When noise is small, there is always a unique equilibrium. Note that the statement by Jorion (2002, pp. 120) "Heinemann (2000), for example, has shown that the conclusions of Morris and Shin (1998), which are the basis for their more recent paper, can be overturned in a more general model." is apparently based on misunderstanding. Moreover, Heinemann and Illing (2002) show that this solution can be obtained as an iterated dominance solution.

against nature and other agents, simultaneously.

The key innovation of MS is in identifying a model where one equilibrium, and thus one price, characterizes the model solution. This unique equilibrium emerges because agents use *switching strategies*, where agents change positions depending on their view of the fundamentals and each other.

In their model, in the minds of market participants, market fundamentals vie with the opinions of other market participants as a guide to investment strategy. Each agent makes a decision based on his view of the fundamentals, where he also explicitly considers that other agents are doing exactly the same. In this case, the actions of various market participants become mutually reinforcing. However, while most information is common to all market participants, some is not. This can happen because the sheer volume of information is so overwhelming that no single agent can absorb it. These assumptions lead to one equilibrium. MS tackle this problem with a unique theoretic device called *global games*.

The intuition behind the global games model can be demonstrated by analyzing speculative attacks on a currency. Suppose that some financial institutions regard a particular currency overvalued, and attempt to exploit this, perhaps by selling the currency in futures markets. If however other market participants do not share this opinion, the trading strategy may lead to losses. In contrast, if many or most other market participants agree, and execute similar trading strategies, this becomes a self–fulfilling prophecy, the currency becomes a subject to a speculative attack, possibly leading to a devaluation. In this case, a small change in the external environment can *trigger* a large and sudden change in the actions of market participants. For example, suppose exchange rates are at a particular level, a small remark by a government official can trigger an instant big change in exchange rates.

2.2 Surprising Consequences of Risk Constraints

A related question is how imposing risk constraints on optimizing economic agents alters their behavior. Daníelsson and Zigrand (2003) (DZ) address this question in a general equilibrium model. Their model is a standard general equilibrium model, providing baseline results. They follow common modelling practice by endowing financial institutions with their own utility functions (such as in Basak and Shapiro, 2001). The effects of externally imposed risk constraints are analyzed by subjecting some, but not necessarily all financial institutions to value–at–risk (VaR) type risk constraints. While it is to be expected that a constrained general equilibrium model will generate qualitatively different results than an unconstrained model, some of the implications of risk constraints are quite interesting.

The benchmark DZ model is a standard two period general equilibrium model with heterogeneous risk averse agents and noise traders. In the first period agents have heterogeneous random endowments of a number of risky assets as well as a riskless asset. The risky assets provide normally distributed payoffs in the second period. The agents are also heterogeneous in risk aversion, and have CARA utility. The noise traders simply submit market orders. This in turn induces trading, price formation, and a price volatility level. Note that market clearing is assured. The benchmark economy results in first–best outcomes and hence has no externalities that merit regulation.

DZ consider systemic crisis to be an event where the entire financial system collapses, capturing an event where the real outputs of all assets drops to zero. A free-riding externality induces agents to disregard the eventual effects of their actions on the global system. The probability of a systemic crash increases along with imbalances in agents risk taking. This is a stylized way of capturing the domino effects resulting from the failure of extremely levered financial institutions. This gives rise to externalities because market participants do not internalize this domino effect into their optimization. Their notion of extreme risk taking increasing systemic risk is analogous to a Lucas (1978) tree asset economy.

In theory, this formulation of systemic crises would suggest some form of optimal regulation. DZ however focus on the general framework of the 1996 Amendment and the Basel–II proposals (VaR), and limit the amount of risk agents are allowed to bear. Providing that these risk constraints are sufficiently restrictive, such regulation can effectively reduce or even eliminate systemic risk due to excessive risk taking.

Imposing Basel style constraints on the benchmark economy obviously has real consequences on outcomes, and a detailed understanding of these secondary impacts is essential for the effective evaluation of the pros and cons of the chosen regulatory structure. In the risk-constrained economy risk-sharing, risk premia, volatility, liquidity, asset price comovement, and market clearing are all affected. Furthermore, the tighter the constraint, the greater the impact becomes.

Compared to the benchmark economy, market prices and liquidity will be lower in the regulated economy with volatility and expected excess returns higher. This is reminiscent of the effect of portfolio insurance on optimal asset holdings found in (see e.g. Grossman and Zhou, 1996; Basak and Shapiro, 1995; Gennotte and Leland, 1990). Note that the constraint in this case is different than in Basak (2002) explaining why his results are different.

Even if assets have independent payoffs, sufficiently binding regulations will cause some agents to adjust their risk position by scaling down their holdings in the risky assets, thereby introducing comovements. This effect will be most pronounced during financial crisis, introducing the potential for an endogenous increase in correlation. In their final result, DZ demonstrate that risk constraints may prevent market clearing in some circumstances. Furthermore, the probability of markets not clearing increases with the tightness of the risk constraint. The only way to ensure market clearing in all circumstances is to exempt some institutions from risk constraints.

2.3 Incentives for Effective Risk Management

Daníelsson et al. (2002) study the impact of risk based supervision on a financial institution's preference for alternative risk management systems. They model the bank as a principal–agent relation between a bank's board of directors (principal) and a dedicated risk manager (agent), where the bank is subject to risk regulation. They consider two alternative categories of risk management systems, one with *fine risk monitoring* and the other with *coarse risk monitoring*. These systems are based on the IRB and standard approaches, respectively.

They reach three main results. First, in the absence of regulatory supervision, financial institutions prefer the higher quality *fine* system, if the direct costs of such a system are sufficiently low. Second, the addition of regulation may cause the financial institutions to reverse this choice, i.e. financial risk regulation provides incentives for banks to implement a lower quality risk management system than they would in the absence of regulation. Finally, when the supervisor decides to affect the implementation of the system, he affects asset volatility and hence introduces procyclicality.

3 Risk is Endogenous

Most, if not all, risk management models in operation are implicitly based on the assumption that financial institutions are price takers, i.e., the financial institution can measure the statistical properties of prices, and forecast some of these properties, but does not influence them. From the point of view of individual financial institutions, these assumptions are relatively innocuous, especially in times of stability. A fundamental assumption in these models is that they are backward looking, i.e., risk is forecasted and the models designed and tested with historical data. A good example of such methodology is value–at–risk, (see Appendix A for more details on VaR.). Indeed, such backward looking statistical models can provide a relatively accurate measures of risk, especially when advanced modelling techniques are employed, explicitly addressing non–normality and non-linear dependence. In day-to-day applications, such as pricing or hedging, assuming that prices are exogenous is typically a simplifying assumption in the modelling process, and incorporating endogeneity or liquidity risk may not be of much value. In this, the risk models resemble the old-style macro models of the 1950s and '60s, which were effectively put to rest by economic events in the '70s and rational expectations economics.

It is however important to recognize that risk is not exogenous and that the endogeneity appears at the worst moment, when markets are unstable or in crisis. It is of course this property of endogenous risk that makes it so hard to model because very few financial crisis are observed, and it's not possible to effectively model statistically the endogeneity when markets are more stable. The nature of endogenous risk can be illustrated by real world examples, e.g., the 1987 crash, the 1998 Russia/LTCM crisis, and the 1998 yen/dollar carry trades.

3.1 The 1987 crash

No consensus exists about the causes of the 1987 stock market crash, and several plausible explanations have been advanced. Indeed, it is likely that several factors contributed to the crash. It is however clear, (see e.g. Brady Commission, 1988; Shiller, 1987), that a major contributory factor to the 1987 crash was the use of portfolio insurance for the dynamic replication of put options.[5] When the market was generally on the rise, executing these trading strategies was a simple matter, however, when the market started falling, everybody employing portfolio insurance had to execute similar trading strategies. Effectively, a large number of market participants were acting

[5]The actual causes of 87 crash are still controversial. In particular, empirical studies of the crash have met with limited success. Furthermore, Roll (1988, 1989) argues that (US) domestic explanations for the crash are not valid because of the international nature of the crash, i.e., all major markets experienced the crash at the same time. However, this argument ignores the price dominance the U.S. equity markets have over the rest of the world. By focusing on daily data, Roll's is affected by asymmetry in exchange opening hours, and the relative coarse granularity is observation frequency implies that it is impossible to observe causality patterns which are likely to happen intraday, and wash out in the daily aggregate.

as one.

According to the Brady Commission about \$60–\$90 billion was in formal portfolio insurance, or about 3% of pre–crash market cap. On Oct 14 1987 (Wedesday) to Oct 16 (Friday) market decline was 10%, and sales dictated by dynamic hedging, were \$12bn. while actual sales (cash + futures), were \$4bn., implying substantial pent up selling pressure the next Monday.

Portfolio insurance implies using the option *delta* as a key part of dynamic hedging portfolio management. When the stock price falls, delta increases, and investors needs to either sell the stock or acquire more of the hedge to retain the insurance. Conversely, if the stock price increases the investors would sell the hedge and buy the stock. Therefore, portfolio insurance is a sell cheap— buy expensive trading strategy. During the crash, portfolio insurance contributed to the formation of a vicious feedback loop between prices, volatility, and liquidity. The recovery of the market soon after the crash implies that no fundamental factors were responsible.

3.2 The 1998 Russia/LTCM crisis

Endogenous risk also played a key role in the 1998 Long Term Capital Management (LTCM)/Russia crisis. A key LTCM trading strategy was *carry trades* and *convergence trades*, for example on the run—off the run treasuries. The success of LTCM attracted competition both from other hedge funds as well as the proprietary trading desks of commercial banks. As a result, spreads were narrowing, and LTCM was forced to venture into uncharted territory in search of profitable trades. One important bet made by LTCM was volatility, which was close to its historical high in the summer of 1998, and at its second highest monthly volatility since the great depression, after October 1987.. Contrary to expectations, volatility did not decline, and in late summer LTCM was extremely levered. It only took a small shock, i.e. the Russian default, to trigger the crisis. In a stylized scenario, whilst extremely levered, LTCM received margin calls, forcing it to unwind leveraged trades, causing prices to drop further, causing more distress, and more margin calls. A vicious feedback loop was formed because of the mutually reinforcing effect of de–leveraging. Furthermore, distress and margin calls entails increasingly short trading horizons. Was LTCM just hugely unlucky? What is the probability of experiencing the price moves seen in 1998? By looking at historical data prior to the crisis, it looks like LTCM was hit by “a perfect storm”. However, by analyzing this from an endogenous risk point of view, the probability of the crisis was very high.

3.3 The Yen/Dollar Carry Trades in 1998

Related factors were at work in the yen/dollar crisis in 1998. Coming after the Asian crisis, Japanese interest rates were much lower than U.S. interest rates, while at the same time the Japanese economy was much weaker than the U.S. economy, implying that the yen could be expected to depreciate. This suggests a particular trading strategy, i.e., carry trades. Borrow yen at the low Japanese interest rate, exchange them into dollars and earn the higher U.S. rates. By this a speculator gains both on interest rate differential and the depreciation of the yen. This trading strategy was profitable in the first half of 1998 as the yen continued to depreciate. This situation was however unstable. A small appreciation in the yen led to margin calls for some speculators who had to reverse out of the strategy, buy yen and sell dollars leading to further appreciation of the yen, more distress, and more margin calls. A vicious cycle was formed.

3.4 Analysis

Both the theoretical analysis and the examples presented above suggests that it would be a folly to ignore endogenous risk. It might be relatively innocuous in stable market conditions to assume that prices are exogenous, however, it is important to recognize that the endogeneity of risk is always present, it is simply less visible when markets are stable. There are three main factors that determine the importance of endogenous risk:

(i) Diversity of beliefs

(ii) Diversity of actions

(iii) Length of horizon (leverage, regulation)

In normal market conditions the actions of market participants are sufficiently diverse for risk to be effectively exogenous. It is however in a crisis situation that price endogeneity becomes crucially important. At the onset of crisis market participants note the increase in risk (less diversity of beliefs), and hedge against it (less diversity of actions). At the same time risk limits and margin calls shorten the time horizon. These factors exasperate the crisis, reinforcing the actions of the market participants. In other words, a vicious cycle between prices, volatility, and liquidity is established.

4 Statistical Properties of Market Prices

In analyzing the effectiveness of risk management systems and regulatory designs, it is important to consider the statistical properties of data generated by financial markets, e.g. risk clustering, fat tails, and non–linear dependence. Any risk model needs to incorporate these effects if it is to provide reliable answers. Furthermore, given the rapid development of statistical methods for measuring financial risk, sufficient flexibility needs to be built into the actual regulatory methodologies.

The key problem in modelling financial risk arises because risk is a latent process implying that it can't be measured directly, instead it has to be inferred incorrectly from market prices. Complicating this is the fact that models have to be designed and tested with historical data, indeed, given the need for backtesting were statistical accuracy dictates a sufficient number of "violations". Backtesting a VaR model at the 99% significance level requires more than 10 violations or thousand days (four years) of daily observations. Reserving one year for model estimation risk models implies that in general risk models are created with data that is more than five years old. Granger and Timmermann (2002) argue that searching for violations of market efficiency with old data and new technology is somewhat contradictory. I suspect the same might apply to financial risk because financial institutions are constantly improving their risk forecast models invariably affecting prices in the process.

The main stylized facts about financial returns are risk clustering, fat tails, and non–linear dependence.

4.1 Risk Clustering

It is well known that financial returns have risk or volatility clusters, a property exploited by Engle (1982) ARCH model. Unfortunately, volatility clusters are not regular, not only does the return data have long run clusters, spanning years or decades (see Figure XXX), it also has much shorter clusters spanning days. This implies that forecasting volatility is very imprecise, in some cases volatility forecasts appear to be as uncertain as the underlying returns data. Volatility models are highly dependent on the estimation horizon because the model parameters give the steady-state to which short-term shocks revert to. It is however in the forecasting of covariance matrices that volatility models become much more unreliable because the only way to estimate large covariance matrices is by using factor models, which effectively model the aggregate behavior and not the dynamic interactions between two assets. In addition, multivariate volatility analysis depends on a linear dependence, which is known not to hold for financial data.

4.2 Fat Tails

A key property of financial returns data is fat tails, implying that outliers or extreme events are much more likely than for normally distributed data with the same mean and variance. The difference between the actual return distribution and the normal distribution is substantial. Consider, e.g., Figure 2 on page 21 which shows the daily S&P 500 return from 1929 to 2003. Superimposed on figure are the standard errors of the data. The largest one day drop is in 1987 which is 20 standard errors (sigmas) from the mean. Under the normal distribution a 20 sigma event occurs every 4×10^{88} days. In contrast, the earth is estimated to be about 10^{14} days old, and the universe 10^{17} days old. Similarly, a 5 sigma event under the normal distribution happens once every 3×10^{6} days or once in 10,000 years. The data sample contains about 30 5 sigma events since years. Similar results apply to other financial data.

This suggests that methods depending on volatility, either directly, or indirectly (like typical implementations of VaR) are bound to be unreliable.[6]

4.3 Non–Linear Dependence

The most important stylized fact about financial return data, at least from a supervisory point of view, must be non-linear dependence. Embrechts et al. (2000) identify three fallacies about financial data:

Fallacy 1 Marginal distributions and their correlation matrix uniquely determine the joint distribution. This is true for elliptical families, but wrong in general

Fallacy 2 Suppose that we have $\mathrm{VaR}\,(X)$ and $\mathrm{VaR}\,(Y)$. Is the VaR of the sum $\mathrm{VaR}\,(X+Y) \leq \mathrm{VaR}\,(X) + \mathrm{VaR}\,(Y)$? This is true for elliptical families, but wrong in general (noncoherence of VaR)

Fallacy 3 Small correlation of (X, Y) implies that X and X are close to being independent. This is true for elliptical families, but wrong in general , see Example 1 on the next page

[6] Conditional volatility models do not generally perform well in forecasting the risk of extreme outcomes

Example 1 *Suppose we have 2 countries, with risk factors X and Y, respectively. Define the random variable $Z \sim \mathcal{N}(0,1)$ and the* contagion generator $U \sim UNIF(\{-1,+1\})$, $\Pr(U=-1) = 1/2 = \Pr(U=1)$, *and independent from Z. Let $X = Z \sim \mathcal{N}(0,1)$ and $Y = UZ \sim \mathcal{N}(0,1)$. It is clear that the two country risk factors X and Y are uncorrelated because* $\mathrm{Cov}\,(X,Y) = E\,(XY) = E\,(UZ^2) = E(U)E(Z^2) = 0$. *Hence $\rho\,(X,Y) = 0$. However, X and X are strongly dependent: with 50% probability* comonotone, *with 50%* countermonotone *Note that X and Y are not jointly normally distributed. See Figure 3 on page 21.*

Financial data is in general non-linearly dependent, implying that linear measures of dependence, i.e., correlations do not show the full picture. For example, several studies have demonstrated that dependence is much stronger in the lower tail than in the upper tail, implying that when markets are generally increasing some assets increase in values whilst others decrease. In contrast, when markets are dropping, most assets fall together. As a result, correlations overestimate diversification effects when markets are rising and underestimate joint downside risk when markets fall.

Non-linear dependence further demonstrates the problem with relying on correlations in designing stress tests. Almost regardless of the marginal distributions, if different assets are linked together by linear dependence only, there is almost a zero probability of them falling together.

4.4 Analysis

Recently, much research on statistical risk measures has emerged, from theoretical, empirical, and practitioner points of view. Issues such as fat tails and non-linear dependence are now widely understood, and risk models incorporate them whenever they can. Unfortunately, despite of all these risk modelling techniques, accurate risk measurements are as elusive as ever. The new models may provide accurate risk forecasts for historical data, but less so for future risk. There are many reasons for this, e.g., increased sophistication in financial products and trading systems, implies that risk models are always catching up. But the quality of risk forecasts depends very much on the risk level.

Modern models can now provide robust risk forecasts for relatively low risk levels, such as 90% or 95%, even up to the regulatory 99%. It is important to keep in mind that at a daily frequency these probabilities correspond to the worst outcome in two-weeks, one month, and five months respectively. From the point of view of internal risk management this may be sufficient.

However, the fact remains that a financial institution violating its 99% VaR has little bearing on its overall stability. Indeed, it is the extreme risk levels, the once a year event, or the once a decade event, that are relevant from a systemic risk point of view. Unfortunately, forecasting risk at those levels is somewhat challenging.

The presence of non-linear dependence in financial data is perhaps even more insidious than fat tails because non-linear dependence can be harder to detect and is more difficult to model than fat tails. The implications of non-linear dependence are however quite severe. It implies that financial institutions underestimate the joint risk of extreme outcomes, and that supervisors may underestimate systemic risk. Much discussion about dependence between different assets, portfolios, or institutions focuses on correlations. Unfortunately, correlations are an *average* concept, describing relationships in the typical situation. Financial crises are nothing but typical. Relying on the average measurement of dependence implies under appreciating downside risk in markets under stress. Hence, ignoring non-linear dependence provides a sense of false security.

5 Procyclicality and Basel

The Basel Committee has adopted these assumptions whilst designing Basel–II, in particular the idea that prices are exogenous. This implies that, banks are price takers, able to measure prices and risk, hedge against risk, but not affect the statistical properties of prices and risk in any way. There is, however, no *a priori* reason to believe that this is correct. For example, while each bank may be viewed as a price taker, in aggregate that is not true. If regulations make banks behave in a more similar way than before, prices can no longer be viewed as exogenous, and a direct feedback loop from regulations to prices is established.

The intuition of the theoretical models discussed above cast considerable doubt over the validity of backward looking risk models as a regulatory tool. Suppose that observations on past market prices show nothing out of the ordinary, and as a result, risk models forecast business as usual. Furthermore suppose that some market participants believe a crisis is imminent, and that this view is spreading. If a sufficient number of financial institutions share this view, it becomes rational to act on it by altering the asset mix, hedging against downside losses, and selling risky assets. This in turn can be sufficient to actually trigger the crisis. In this case, backward looking risk models show nothing out of the ordinary, while the actual probability of a market crash steadily increases.

The primary causal effect is the harmonization of preferences that the crisis brings about, and the resulting herding behavior of market participants. The effects of this preference harmonization are especially important for volatility and liquidity, or as stated by Committee on the Global Financial System (1999) in the“five guiding principles for the design of deep and liquid markets” including “heterogeneity of market participants”.

5.1 Other Views on Basel–II

The complexity of the Basel–II is e.g. addressed by the General Manager of the BIS:

> “To the criticism of complexity, there are two answers. First, banking itself has become more complex. ... The second answer is that, for banks with straightforward business models and non-complex loan portfolios, the new accord really adds very little in the way of complexity.”
>
> Crockett (2003).

Other supervisors appear to disagree with this view:

> “I have consistently expressed profound concern about the level of detail and specificity of the Basel proposal. In my view, the complexity generated in Basel II goes well beyond what is reasonably needed to implement sensible capital regulation.”
>
> Hawke (2003) Comptroller of the Currency

These arguments for procyclicality are of course controversial. While I am not aware of many studies arguing that these arguments are wrong, some opposing views have been expressed. Within the academic community Jorion (2002) states:

> “The vicious circle argument for market risk charges, however, is being generalized to credit risk as a criticism of any risk-sensitive capital requirements. We should also note, however, that such criticisms fail to offer plausible alternatives. The history of failures in banking systems and enormous costs on the economy provides a powerful rationale for regulation. Having no capital requirement at all is not realistic.”

> Jorion (2002)

At least two supervisors have expressed their disagreement with analysis of the type presented above:

> "First, the sophistication and structure of risk-management models vary widely. This point applies with full force to value-at-risk models in use at commercial banks, an area the Federal Reserve has some knowledge of through our supervisory oversight. Our examiners have observed that banks implement a common objective–measuring the value-at-risk of the bank's trading account in highly diverse ways. Given their early stage of development and the diversity with which they are implemented, the use of these models does not seem likely to create herding behavior.
>
> Second, other sources of diversity exist among financial firms, including differences in risk appetites, customer bases, and product lines. These additional sources of variation create considerable heterogeneity in financial firms' trading strategies, in their risk-taking, and in how they respond to market shocks.
>
> Finally, ... risk models are never likely to be the dominant driver of the actions of financial firms and are therefore unlikely to generate significant herding behavior."
>
> Ferguson (2002), Vice Chairman of the Board of Governors of the Federal Reserve System

> "A second criticism is that the new accord might reinforce procyclicality in financial behaviour.... A first point to make in response to this criticism is that procyclical behaviour of this type is endemic to financial systems, and not simply the result of regulatory requirements. Of course, it is important that regulation does not inadvertently amplify the economic cycle. Several approaches can help here, and have been incorporated by the Basel Committee. Firstly, it can be made clear that minimum capital requirements are just that - minimum requirements. ... Second, capital requirements under Pillar I of the accord should not be applied blindly or mechanically. ... Third, it is desirable to use measures of credit risk that are not excessively vulnerable to short-term revisions.
>
> Crockett (2003) The General Manager of the Bank for International Settlements.

These responses fall roughly into three categories. Jorion argues that Basel–II is better than having no regulation, while Ferguson refers to Fed evidence of banks being really heterogeneous, and stating that risk models are not all that important anyway, a view echoed by Crockett who argues that Basel–II only specifies minimum capital, and that intelligent implementations and risk measurements have already been incorporated by the Basel Committee. Of these comments, only Ferguson provides any tangible evidence when he refers to the experience of Federal Reserve bank examiners.

It would be much better if more concrete evidence against the procyclicality argument was available, perhaps financial economic research or statistical evidence. Unfortunately, the supervisors have not done so yet, casting some doubt on their criticism of procyclicality.

Indeed, I remain unconvinced by statements such as

> "Overall, it is fair to conclude that there is no evidence to support the assertion that VaR-based risk management systems destabilize the financial system." Jorion (2002)

that are not backed up by any hard evidence.

5.2 Stress Testing

The potential for procyclicality is downplayed by the Basel Committee (2002) when it states that "To help address potential concerns about the cyclicality of the IRB approaches" banks should perform stress testing. Furthermore, Berkowitz and O'Brien (2002) studies the correlations of daily trading revenues for a group of six US commercial banks, and find it to be 12% on average for January 1998 to March 2000, suggesting that on average there is considerable heterogeneity in trading strategies.

This, however, misses the point, the focus is still on the institution level risk, and feedback effects are disregarded. Correlations are an average concept, and say little about dependence in times the crisis. Institution level stress testing does not address the core of the problem of endogenous risk or procyclicality. Ideally, the supervisors should run systemwide stress tests. This has been considered by the CGFS, but ultimately dismissed, "The group concluded that, under ideal circumstances, aggregate stress tests could potentially provide useful information in a number of areas. ... However, the group also noted that it is as yet unclear whether such ideal circumstances prevail." Committee on the Global Financial System (2000).

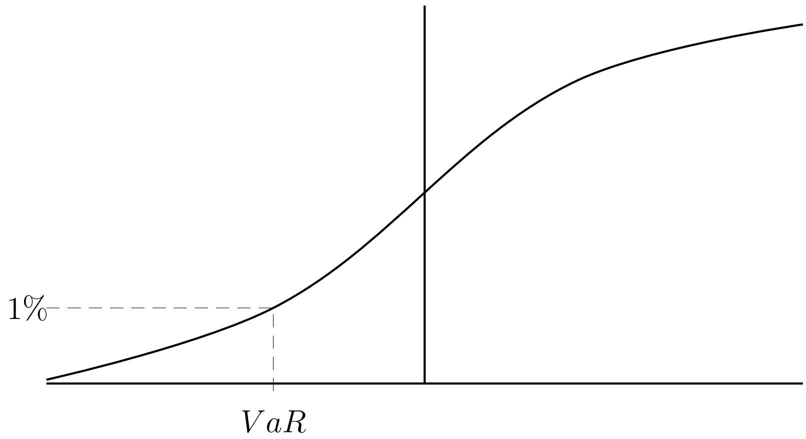
Related is the question of effectiveness of stress tests, even the absence of endogenous risk. A common practice is to use some heavy tailed data (heavy tailed marginal distributions) and implement dependence by using correlation matrices. Unfortunately, almost regardless of the correlation coefficient and tail fatness, the probability of a joint extreme drop is very low. It is essential to incorporate non-linear dependence in the design of stress tests to effectively capture the joint extreme price drops across assets observed in market crashes. This is still very uncommon and supervisors have been silent on this issue.

6 Conclusion

New research argues that Basel–II might have far reaching and unexpected economic implications. Of these, the most important is the potential of Basel–II to introduce procyclicality and endogenous feedback loops between prices, volatility, and liquidity. In particular, Basel–II may perversely amplify the riskiness of the financial system, by increasing the frequency and depth of financial crisis.

We simply do not know enough about the nature of risk, be it from a theoretical or empirical parts of view, for us to be able to create an effective regulatory mechanism. Given evidence that the Basel–II cure might be worse for the patient than the decease, it is incumbent upon the Basel Committee to properly address those issues. Either the procyclicality argument is proven wrong, or endogenous risk should be explicitly modelled and incorporated in Basel–II.

Figure 1: VaR and Profit and Loss Distribution



Appendix A Statistical Risk Models

The primary statistical tool for measuring market risk is *value–at–risk* (VaR). The reasons for the popularity of VaR are many, but two are the most important. First, it is specified by regulators (Basel Committee, 1996). Second, of possible risk measures, it has the largest set of desirable properties. In particular, since volatility is a very imperfect measure of risk due to its dependence on normality for interpretation, VaR is perhaps the easiest of the distribution independent risk measures to implement. The former definition of VaR is:

$$p = \int_{-\infty}^{\text{VaR}} f(x)dx$$

Where p is a probability level, typically 1% and $f(x)$ is the pdf of profit and loss. Graphically, this can be shown graphically by Figure 1.

In general, the pdf of profit and loss is estimated by statistical methods only using historical values of the assets. The Basel regulations require at least one year of daily data in the estimation, and most national supervisors do not allow banks to use more than one year. For details on VaR, especially the pros and cons, see e.g. Daníelsson (2002).

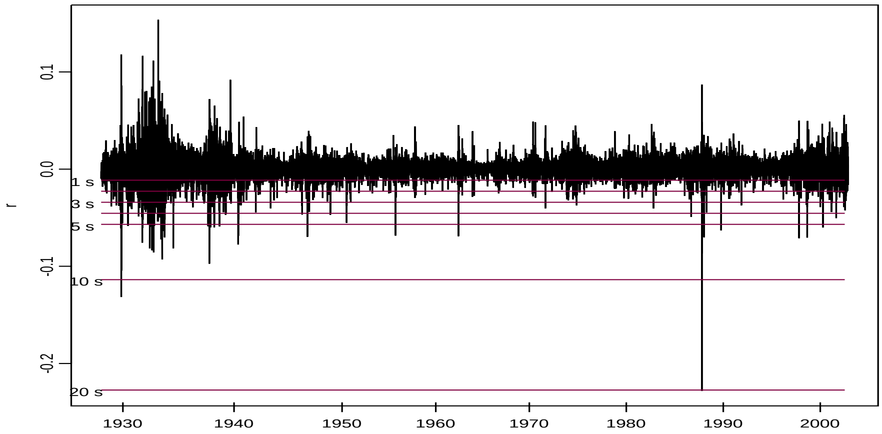


Figure 2: S&P–500 Index returns: 1928 to 2003 with superimposed sigma events.

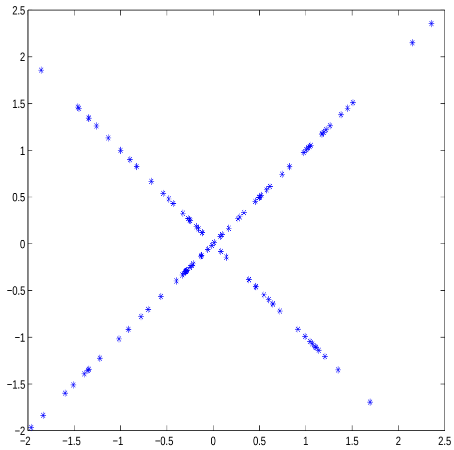


Figure 3: Contagion example

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