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Operational Risk Management

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Summary

We view risk management as an integral part of good management. Risk management should take a balanced view of decision problems encompassing all significant risks and rewards. Operational risks are only one type of risks and therefore are only one piece in the jigsaw puzzle that only makes sense when all pieces are assembled. All risk analyses are based on the same general principles – generation of alternatives, quantification of uncertainties and preferences, modeling of consequences – but factors deserving the most attention vary from problem to problem. We distinguish three broad types of operational risks according to the frequencies of loss events: nominal, ordinary and exceptional. Depending on the type, uncertainties are negligible, similar or very large compared to expected losses. Nominal risks are the province of Total Quality Management, a well-developed discipline, but perhaps better known in manufacturing than in financial services. The analysis of ordinary and exceptional risks is illustrated by case studies from which we draw general lessons. With ordinary risks, it is crucial to understand the interaction among risks and with costs and rewards; risks do not add up, indeed operational risks may sometime reduce other uncertainties. With exceptional risks, we show the importance of quantifying the risk attitude of a financial institution in order to arrive at rational decisions such as mitigation or transfer of risks.

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Risk Management - An Integral Part of Good Management

The debate between regulators and bankers over the last fifteen years or so has been a powerful driver for the development of better risk management and consequently greater efficiency in the use of capital resources in the banking industry. It matters more to see new initiatives in this growing field than to argue where they should come from, as long as the two sides can agree and keep up with each other. But do they really agree or are they just pretending to agree? Are the objectives of the regulator and those of the banker sufficiently in line to ensure frank and open cooperation?

What is good risk management for a banker and why is it so important? Personally, I do not see any distinction between good management and good risk management in a world where most important decisions have uncertain outcomes. If we could know precisely the consequences of our actions, good management would reduce to (i) generating attractive alternatives and (ii) agreeing on preferences among various possible outcomes. A good decision would simply be the choice of the alternative leading to the preferred outcome; that would be the 'rational' choice; one may dispute the limits of rationality, yet no manager would favour 'irrationality'. But when do we know precisely the consequences of our actions except in trivial cases? Significant management decisions are taken in the context of complex systems where outcomes result from the interaction of many factors not known with certainty, including decisions from other economic agents. Thus management must also be good at (iii) identifying and framing the problems to be addressed (iv) translating limited information into quantitative probability assessments (v) expressing preferences not only among various outcomes but also between various combinations of outcomes with different probabilities, what is called risk-preference. In an uncertain world, good decisions no longer equate to good outcomes and good management becomes synonymous with good risk management. Risk management is much more than assessing, reporting and controlling risks[1].

It would be a tragedy if, somehow, risk management was seen as a discipline divorced from that of management when it should be an integral part of it. Alas, there are already signs of separation. True, risk management requires that certain specific tasks be carried out by qualified staff supervised by independent managers with wide rights of access to information, but the support functions including model building, monitoring and reporting, should not be confused with risk management itself. In too many banks, risk management is now seen as the task of one department alongside other departments fulfilling other support functions such as human resources management and information systems. Whether it is seen as a luxury or a mere necessity (to satisfy regulators) is questionable. It is certainly regarded as a cost center for, perhaps, a not so crucial service; witness crises when the risk management department is often among the first to be pared down.

The separation is encouraged by supervisors as well as by internal forces. Banking supervisors are more concerned with protecting depositors, investors and other creditors than with maximizing returns to shareholders or providing better performance for customers. So, supervisors take a prudent, one-sided view: limit the probability of insolvency and ensure that risks are assessed as objectively as possible. It follows that risk assessments should be carried out by staff not reporting to front office managers and not directly and immediately interested in the results of the bank. It follows also that supervisors prefer to focus on 'measures' (their word) of risk that, they hope, can be obtained objectively and independently of wider performance measures.

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[1] For a primer in decision analysis see Howard [1] and for further developments and applications see Howard and Matheson [2]

Tradition and internal politics conspire with supervisors to isolate the risk management function. In a foregone age of credit controls and rationing rather than pricing, credit risks were first sorted out as acceptable or not. Not so long ago (perhaps even now), many banking supervisors wanted the chief credit officer of a bank to have the ultimate responsibility for such decisions. Paradoxically, senior management often agrees with this division of responsibilities and even welcomes it for the screening of all sorts of risks. At first, one may wonder why senior management would want to delegate such important decisions. On second thought, one realizes that senior management may find two advantages in this approach: (i) if a prospect is not rejected, they have freer hands as they no longer have to worry about risks; should a bad outcome ensue, it is the prime responsibility of the risk manager who failed to reject the prospect; (ii) if a prospect is rejected as too risky, they do not have to consider difficult trade-offs between risks and rewards. Of course, this approach would fail if credit officers and other risk managers, having no incentive to accept risky prospects but only fearing potential blame, would reject them all. But that is not realistic; risk managers would rapidly loose their credibility and suffer the general opprobrium of their colleagues in profit centers. They have to accept a decent proportion of all opportunities submitted to their review. Unfortunately, they must decide without having all the elements necessary to make a rational choice. Their decisions have to be arbitrary to some degree.

The reluctance to make trade-offs between risks and rewards is not specific to managers in the financial industry. It is a pervasive modern day pathology; in fact, it is probably less pronounced in the financial industry where outcomes are readily measured in cash flows than it is in other fields where say, moral values or human lives may be at stake[2]. There is even reluctance in some firms to be seen as making decisions at all. Business decisions are irreversible allocations of resources; small or large, they shape the future of a company. But instead of focusing on decisions, many ‘managers’ prefer to talk about management ‘framework’ and ‘processes’ for ‘monitoring’ and ‘control’.

Two root causes of this disease are (i) judging people on results – because senior managers do not know any better – rather than on the quality of their decisions; then survival instincts will naturally lead managers to avoid making decisions or to be over-conservative, and (ii) fragmentation of responsibilities leaving decision makers not only with partial information but also with limited objectives. Banking supervisors should avoid reinforcing these regrettable tendencies.

Nominal, Ordinary and Exceptional Operational Risks

The starting point of good management is to focus attention on critical issues by which I mean situations where good ideas and good decisions can make a difference. There is no point worrying about things that cannot be controlled nor any commercial value in gathering information unless it may affect some decisions (learning for pleasure is a different matter).

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[2] Can we put a price on freedom or human life? Many find the question preposterous, so it remains unanswered. But medical doctors and politicians, among others, face situations requiring such value judgments. Unable to rely on reasoned and publicly agreed views, they must rely on their own judgment. Politicians even find it advantageous at times to play on public emotions (e.g., following a major accident) by declaring proudly that they refuse to put any price on human life (e.g., “We shall not compromise safety” or “Safety is our only priority, regardless of costs”) or that nothing will stop them to preserve freedom. An intelligent public should ask the exponents of such glaring abdications of responsibility to resign.

Events may command attention to particular problems but many opportunities may be missed or alternatives become unavailable unless one tries to think ahead about critical issues. At any rate, rarely do problems come well defined and neatly framed as in textbooks. An open, attentive, inquisitive and creative mind and broad experience are prime qualities for a good decision maker.

But good individuals cannot succeed in bad organizations. Some types of internal organization and company culture foster forward thinking whereas others stifle it. An organization where functions and responsibilities are highly fragmented, where internal communications are limited and codified, where individualism is encouraged more than cooperation, where objectives are not clearly defined and shared, where staff and managers are too busy with immediate tasks to look at what is happening around them, where blame is more readily attributed than rewards, where there is no service ethics, where some key executives have an unquestionable authority… is an organization prone to running blindly into operational accidents.

If, on the other hand, a firm's global objectives and values are understood, managers are encouraged to look beyond their desks, to communicate and to cooperate, if there are checks and balances in the decision making process, if there are individuals (from non-executive board members to junior employees) who are given time to think about the future and alternative ways of doing business and proper forums to discuss new ideas, then, such a firm is less likely to be caught by surprise and more likely to develop efficient ways of doing business.

Thus the collection, analysis and reporting of operational loss data is not the be all and end all of operational risk management. At best, it may stimulate reflection about operational problems but it is by no means the only or even the privileged starting point. Consider, for example, the operational loss data assembled in Basel's Second Quantitative Impact Study (QIS2-Tranche2) [3]; there is nothing there to suggest that the responding banks are not controlling properly their operational risks nor any suggestions about what they should do better. Should they pay more attention to operational loss categories[3] where the largest total losses have been recorded? That would be, by business line:

Corporate Finance and Retail Banking:	Clients, Products and Business Services
Trading & Sales and Payment & Settlement:	Execution, Delivery and Process Management
Commercial Banking:	External Fraud

Or should they pay more attention to categories creating the largest uncertainties because of the presence of few but relatively large losses? The main categories would be:

Corporate Finance and Retail Banking:	Clients, Products and Business Services
Trading & Sales:	Internal Fraud
Corporate Finance:	External Fraud

In both cases the figures are not particularly impressive. For an average bank in the sample, the largest loss categories account each for about 0.1% of capital and the largest uncertainties (in standard deviations) about 0.2% of capital. Small numbers indeed compared to expected earnings and earnings variability that are more like 15% and 5% of capital respectively.

[3] QIS2 operational loss data contain 90 bank-years of experience (30 banks over years 1998 to 2000) arrayed according to the 8 business lines and 7 loss types defined by Basel for their proposed Advanced Management Approaches. For the 56 resulting loss categories, total number of loss events with severities above €10,000 and total losses have been recorded.

The debate fueled by the Basel proposals about operational risks will be fruitful if it leads some banks to realize that they have not paid enough attention to this type of risks and the industry to develop appropriate methods to analyse them. An interesting subject then is to explore whether there are generic methodologies to address situations where operational losses play a role. My own view is that it would be useful to distinguish three types of operational risks according to loss frequencies because they reveal different salient features: (i) *Nominal operational risks*, (ii) *ordinary operational risks*, both encompassing the vast majority of all operational risks, typically illustrated by QIS2 loss data, and (iii) *exceptional operational risks*, absent from QIS2, a few instances appearing in much larger databases, but mostly lurking out in the future.

I call *nominal operational risk* the risk of repetitive losses (say losses that may occur on average once a week or more frequently) associated with an ongoing activity, for example, settlement risk, minor external fraud (one credit card lost or stolen every 8 seconds, my bank reminds me!), or human error in transaction processing. Such losses must be taken into consideration in the optimization of processes but they hardly deserve to be called risks for only the expected losses are significant (many times larger than the standard deviation of losses) and should be compared to the cost of controls. We shall not discuss them here, not because the subject is unimportant, but because it has been addressed well elsewhere. There is an excellent literature on the subject of Total Quality Management, a concept first developed by the late Edward Demmings who revolutionized the Japanese industry after WW2. Only later were Demmings' ideas accepted in his home country, the USA. They are now applied successfully in most industrialized countries and most industries (see your local Total Quality Management Group and the TQM journal). A frequent conclusion after studying nominal risks is that they are excessively costly; improved procedures and a better quality culture often proves not only to be less expensive immediately but also to have beneficial long term effects on client relationships and reputation. Many of the methods currently proposed to tackle operational risks in banking are designed to cope with nominal risks, i.e., with expected operational losses. It would not be surprising if many financial institutions came to realize that nominal operational losses are very costly and business could be conducted more efficiently with greater emphasis on quality of services.

Ordinary operational risks I define as the risk of less frequent (say between one a week and one every generation) but larger losses, yet not life threatening for financial institutions. They are usually one among several important consequences of a strategic choice and should be analysed within the wider context of that choice; in particular, the relationships between these risks and other risks associated with to the same strategic choice need to be understood. We give an illustration in the first case study below.

Of the *Exceptional operational risks* (say losses that have no more than a few per cent chances of occurrence over a year) only those that may be life threatening to financial institutions matter. These risks deserve specific attention. We discuss them later and use a second case study in which we illustrate the importance of quantifying a firm's risk appetite to make rational decisions.

On a log-frequency/ log-severity diagram[4], the three main types of operational risks we have just defined could be mapped approximately as in Figure 1. We have also separated out in the

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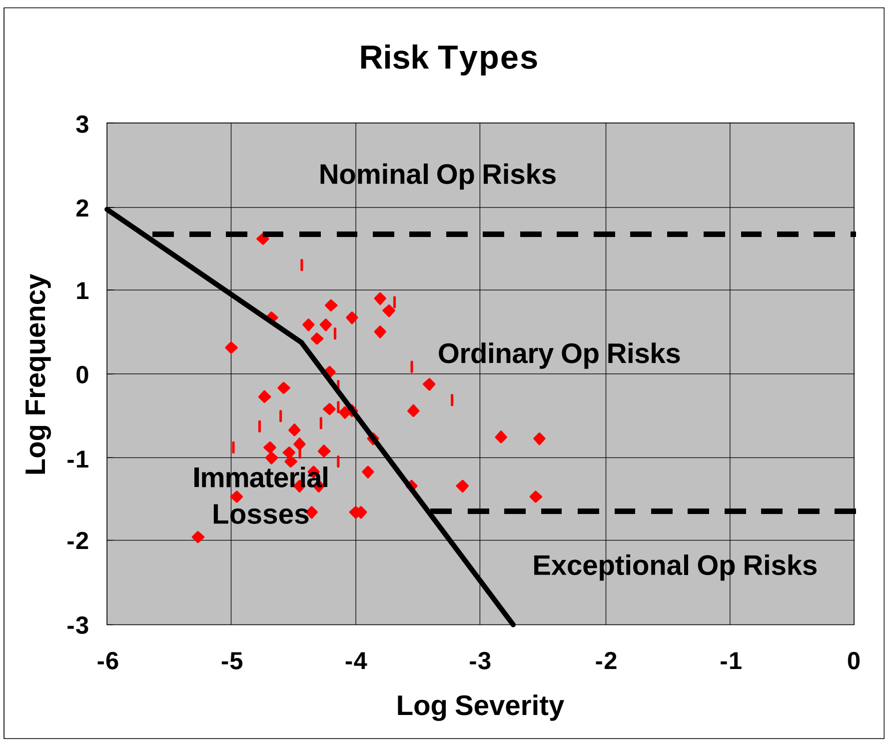
[4] The diagramme displays loss categories on decimal logarithm scales for frequency (vertically) and relative severity (horizontally). The frequencies are calculated by dividing the number of loss events recorded in QIS2 by 90 (the number of bank-years in the database); the relative severities are

lower left-hand corner the loss categories that are too small to be material (we chose to ignore categories where both the expected loss and the standard deviation of losses is less than ten thousandth of the current minimum regulatory capital[5]). Obviously, the boundaries we have drawn are only approximate limits between zones where attention should be given either to expected losses or to risks (i.e., uncertainties), or where these features are negligible. To summarise, for:

Immaterial Losses:	Both expected losses and risks are negligible
Nominal Operational Risks:	Expected losses are much more important than risks
Ordinary Operational Risks:	Both Risks and expected losses are significant
Exceptional Operational Risks:	Risks are much more important than expected losses

More than half the operational losses reported in QIS2 (shown by the small diamonds in Figure 1) fall into the immaterial zone. Not surprisingly, the rest would be classified as Ordinary Operational Risks. The only category near the Nominal Operational Risks boundary is *External Fraud in Retail Banking* although there would have been many nominal risks reported in QIS2 data if it had not been for the cut-off reporting level of €10,000 per loss. The few reported rare risks have low impact and are therefore immaterial. As expected, no truly Exceptional Operational Risks shows up in QIS2 data. The category that would come closest is *External Fraud in Corporate Finance*

Figure 1: Taxonomy of operational risks



calculated by dividing the average loss per loss event by €3 billion, a conservative estimate of the average capital of the banks in the sample.

[5] Minimum regulatory capital (MRC) is defined as the capital requirement for credit and market risks under the Basel I rules to meet the minimum 8% solvency ratio.

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An Ordinary Operational Risk Case Study

We choose an example from the category *Client, Products and Services* in *Corporate Finance,* which appears in both lists of top expected losses and risks[6]. Suppose that within corporate finance, the bond origination department is forecast to win about two mandates per month and that each successful deal brings an average of €4 million in fees. However, a few deals have turned sour over the years because of poor preparation, incorrect pricing, erroneous disclosures, etc. Most of these errors resulted in the bank being unable to place its entire share of the issue at the expected price and losing money on the rump, having to pay additional fees to other managers or, occasionally being sued by investors. The best guesses of managers in the debt origination department is that, given the current organization and market conditions, there may be about one bad case per year with an average loss of €10 million. The bond origination activity employs 100 people and has an expense budget of €30 million. History shows that it has also generated market losses of about 10% of fees on average.

The departmental budget for next year is summarised in Table 1. Note that the case study has been designed to exaggerate operational losses reported in QIS2 for the corresponding category; the frequency of losses has been increased 6 fold and the average severity by 20%.

Table 1: Debt Origination – Base Case Budget

Expected number of mandates	25		
Expected fee per mandate	€4m	Expected revenue	€100m
Operational loss probability	4%		
Expected operational loss per loss event	€10m	Expected operational loss	€10m
Expected market losses (% fee)	10%	Expected market loss	€10m
		Expense budget	€30m
		Expected gross income	€50m

At first sight, this is a good business, good enough for employees to expect bonuses at year-end. Of course, it is not without uncertainties, so we call the budget above the *base case* budget (we cannot pretend at this stage that it is the most likely case or the expected case or anything more significant than a starting point in our analysis).

[6] This example is hypothetical; the figures are purely illustrative and are not meant to reflect the economics of any particular firm

Which uncertainties could have the greatest impact on gross income? It is laborious to translate views into probabilities and it is costly to gather additional information to narrow down uncertainties, so we proceed step by step, starting with a simple, 'back-of-the-envelope' sensitivity analysis to discover the most influential factors[7]. For each of the entries in the budget table above, we ask the relevant managers to state a range of possible variations that would not unduly surprise them, say a range that, in their mind, would have about two chances in three of capturing the correct figure. The answers are given below together with their marginal impact on gross income.

Table 2: Debt Origination – Sensitivities

Key Factors	**Base case**	**Range**		**Gross Income Variations (€m)**	
		Low	**High**		
Number of mandates p.a.	25	18	33	23	81
Average fee per mandate	€4m	€3m	€5m	25	75
Number of operational loss events p.a.	1	0	3	60	30
Average operational loss per loss event	€10m	€5m	€20m	55	40
Average market losses (% fee)	10%	5%	20%	55	40
Expense budget	€30m	€27m	€35m	53	45

The sensitivity table calls for a few remarks:

(i) There is an intrinsic uncertainty in the origination activity. Whilst we may expect and be prepared for 25 mandates per year, each opportunity for a deal and each mandate won is the result of not only hard work but also luck. We could describe the process as a succession of independent mandates won at an average rate of 25 per year. The most general mathematical description of this process is the Poisson process[8]; it implies that for a given average rate, one standard deviation for the actual number of mandates is the square root of the rate of arrival, here 5, which leads to a range of uncertainty on gross income of ± €16m[9]. But in addition management is uncertain about the rate of arrival of mandates. Say they give the rate of arrival a 66% range from 20 to 31. The figures appearing in the range for the number of mandates show approximately the combined effect of these two uncertainties[10].

(ii) Likewise an operational loss rate of 4% on an average of 25 deals, or one loss per year, would also create an intrinsic uncertainty of almost ± 1 loss or ± €10m. The figures shown in the range combine this intrinsic statistical uncertainty with an uncertainty about the operational loss event probability. Note also that the probability of an operational loss may be related to the total number of deals; we shall come back to this point later.

(iii) The sensitivities have been calculated one by one, holding all factors at their base case values except for the one being tested. In reality, factors may move together and, as a

[7] Note that in in the recently developed

[8] The Poisson assumption is probably a slight exaggeration of the uncertainty because the team is likely to work harder and have more time available if few mandates are won, and vice versa.

[9] Revenue per mandate, net of operational and market losses, is €4m – 4%(€10m) – 10%(€4m) = €3.2m or €16m for 5 mandates

[10] A 66% range is about 2 standard deviations but this one is not quite symmetrical around the mean (25-5, 25+6). Combining two independent uncertainties with standard deviations of 5 an 5.5 yields a total standard deviation of 7.4 but due to the asymmetry around the mean, we choose 25-7 and 25+8 as a range.

result, the relative importance of each factor may be different from what it appears to be in the sensitivity table. For example, uncertainties about 'Average market losses' and about 'Average operational loss per loss event' appear to have similar impacts. In reality the uncertainty on market losses may be more significant because it is probably related to the rate of generation of mandates: in lean times, there are not only fewer mandates but also greater placement difficulties leading to potentially greater market losses. An opposite relationship may hold for operational losses: the busier the team the greater the chance of a major error and vice versa. It should also be noted that gross income is not a linear function of all risk factors and therefore the combined effect of several factors may be greater or smaller than the sum of their marginal effects.

Keeping in mind the limitations of the sensitivity analysis, it is still fair to say that the first two factors 'Number of mandates p.a.' and 'Average fee per mandate' have the greatest impact on gross income and management's attention would be well spent finding alternative strategies that could influence these two factors to reduce risks and/or to increase gross income. Alternative strategies could be: a general increase of the departmental resources, new ways of seeking profitable mandates, e.g., concentration of efforts on large deals, strengthening of experience in some country/sector, adjustment of fee/pricing policies, etc… Other factors are less important but, because 'Number of operational loss events p.a." comes third on the list and we are discussing operational risks, let us suppose that a keen operational risk manager has convinced senior management that it seems ridiculous to loose perhaps €10m to €30m per year because of flawed deals. After all, €30m is equal to the expense budget of the department. It would seem that, with a bit more resources and care, such operational losses could be greatly reduced.

To formulate a simple decision, suppose a 20% increase in personnel and other resources is considered at an additional cost of €5m per year. The operational risk manager proposes that the extra resources be used to do a more thorough and professional job and avoid operational losses rather than to try to increase the volume of business – that is alternative A. The head of department proposes to explore also the consequences of using these extra resources to try to capture more business, keeping the working practices unchanged – that is alternative B. We summarise the expected impacts of the two alternatives compared to the status quo in Table 3:

Table 3: Debt Origination – Alternative Strategies

Strategy	**Status Quo**	**Alternative A**	**Alternative B**
Arrival rate of mandates	25	25	28
Operational loss probability per mandate	4%	1%	4%
Expense budget	€30m	€35m	€35m

Under Strategy A, the 20% increase in resources is expected to decrease the probability of making a significant error from 4% down to 1% per deal (it is very hard to eliminate all possibilities of error). Under Strategy B, the number of mandates is expected to increase by only 12% because of stiff competition and limited markets. All other factors except for the €5m increase in expenses remain the same as in the status quo.

A quick reckoning shows that Alternative A achieves an expected operational loss saving of €7.5m (=3%(25x10)) for an extra cost of €5m, whereas Alternative B is expected to increases revenues by €9.6m (=12%(100 – 10 – 10)) for the same extra cost. Prima facie, the two alternatives appear favourable compared to the status quo, but B is not a clear winner as A has been designed to be less risky than the status quo whereas Alternative B will amplify the risks.

Again we try a 'back-of-the-envelope' calculation to determine whether the relative riskiness of the three alternatives might influence our choice. We assume Poisson arrivals of mandates, and, given a mandate, an independent binomial process for the occurrence of a foul up. For each mandate, we assume a fee distribution with standard deviation equal to its expected value and, likewise, for each operational loss, a standard deviation equal to the expected loss. On this basis and including uncertainties for other factors in line with the sensitivity ranges shown in Table 4, we calculate some summary characteristics of the three alternatives to help decide among them[11]:

Table 4: Debt Origination – Evaluation of alternative strategies

Strategy	**Status Quo**	**Alternative A**	**Alternative B**
Expected gross income	€50m	€52.5m	€54.6m
Standard deviation of gross inc.	€37.8m	€36.6m	€40.0m
Probability of negative gross inc.	9.3%	7.6%	8.6%

No great surprise here except perhaps that the risk reduction achieved by the 'safe' Alternative A is only nominal. Indeed, a complete elimination of operational losses, if it were feasible, could be shown to result in a standard deviation of €36.2m, a very small risk reduction compared to €37.8m standard deviation with the status quo. Both Alternatives A and B appear more favourable than the status quo but there is not much to choose between them. A more refined analysis would be necessary (including a better description of objectives, e.g., return on capital, risk attitude, etc.) to arrive at a definitive conclusion[12]. Perhaps more importantly, it would be useful to imagine better alternative strategies or turn management's attention towards more critical problems – all the analysis in the world cannot make up for the lack of one good idea!

This case study is only meant as an illustration but it reveals two general reasons why ordinary operational risks are unlikely to play a significant role in risk management (even when grossly exaggerated compared to recorded loss experience). First, ordinary operational risks are only one type among the many types of risks faced by a firm, including large risks that are not recognized in current and proposed regulations. As we see in our case study, the predominant risks found in the bond origination activity are: number of mandates won and profitability of each mandate; such risks are classified as business risks by Basel and simply ignored under Pillar 1. The second reason is that ordinary operational risks will often be negatively correlated with the main risks. An increase in activity, increasing revenues, is

[11] The specific parameters used in our calculations (other than those already described) are: Standard deviation of rate of arrival of mandates: 20% and standard deviation of expense budget: 8.33%.

[12] It would be improper to say that the choice between 'A' and 'B' is *difficult*; *indifferent* or *not material* would be more apposite.

often linked with an increase in operational risk exposure, be it human error, client fraud, or even system failure. Thus, paradoxically, operational risks could even reduce total risks[13].

The main lesson is that risk management, as part of good management, should be concerned with all aspects of risks and revenues. Ignoring some aspects is likely to lead to poor decisions. Thus the emphasis put by Basel on operational risk could be useful if that aspect was previously overlooked – although there is no evidence that it was; conversely, it could be dangerous if it focused attention too much on this type of risks and away from other risks and costs, for example by requesting a narrowly defined monitoring of operational losses and providing incentives targeted to reduce operational losses without regard to other economic factors. Alas, this is what Pillar 1 does.

Understanding Exceptional Operational Risks

Are there common features among what we called exceptional operational risks beyond their defining characteristics of rarity and severe consequences? Table 5 lists a dozen cases of banking, broking and asset management institutions that were greatly affected by operational losses over the last twelve years. Ten of these went bankrupt, were taken over or were forced to merge as a consequence of their losses. One could not say that these are the most significant operational losses recorded over the period without entering into a debate on ranking criteria (for example: how to account for the impact of the loss, the size of the company, the strength of the operational causality, etc.). Let us say simply that these are representative exceptional operational losses.

It is striking that the twelve cases listed were consequences of deliberate actions and not mere accidents. In at least ten cases these actions were unethical, illegal or criminal [14]. They were not necessarily initiated by senior management, but they were at least allowed to endure by management incompetence or negligence. The root cause, not surprisingly, is individual and corporate greed.

Table 5: Exceptional Operational Risks Illustrations

Company	**Cause of Loss**
(1991) Salomon Brothers (US)	US T-Bond primary market manipulation
(1993) Bank of Commerce and Credit International (BCCI) (Luxembourg)	Illegal activities (drugs, arms)
(1994) Kidder Peabody (US)	Management incompetence

[13] For the sake of curiosity, the reader could modify the parameters of the case study to create an increase in total risks when reducing operational risk. One way is to choose an expected operational loss equal to the expected fee and a standard deviation of operational loss smaller than the expected fee. Another way is to develop a more realistic model showing that the probability of error, for a given department size, increases with the amount of work to be done, that is, with the number of contracts won.

[14] The two special cases are: (i) The September 11 terrorist strike – although it had been planned for years by its perpetrators, it still came as a total surprise to the victims; (ii) The reduced final bonus policy put in place by The Equitable Life Assurance Society to offset the benefits of guaranteed annuity rates given to some policy holders was, in the end, judged illegal by the UK House of Lords but this ruling was difficult to foresee.

(1995) Barings (UK)	Rogue trader and management incompetence
(1995) Daiwa Securities (Japan)	Involvement with gangsters
(1996) Bankers Trust (US)	Selling products clients did not fully understand
(1997) Morgan Grenfell (UK)	Unauthorised investments in illiquid assets
(1997) Natwest Markets (UK)	Mispricing of derivatives
(2000) The Equitable Life Assurance Society (UK)	Non-respect of guaranteed annuity contracts
(2001) Cantor Fitzgerald and others (US)	Terrorist attack on World Trade Center
(2002) Allied Irish Bank (US)	Rogue trader
(2002) Merrill Lynch (US)	Biased analyst recommendations

A second feature of the observed exceptional operational risks is the diversity in their manifestations. The ingenuity of an unscrupulous human mind is unbounded when it comes to devising new ways to profit from an insufficiently controlled environment. Firms are less likely to fall victim to the same scheme than to fall into new traps. With globalisation, new products, new technologies, increased competition and pressure to perform, one may expect new forms of operational risks in the future. The observed heterogeneity of circumstances in which exceptional operational losses have occurred should help exorcise a few ghosts before sketching an appropriate methodology to tackle exceptional operational risks.

The first ghost is the belief that 'industry wide' operational loss databases will provide the basis to assess exceptional risks. Some companies have launched into the collection of operational losses across financial institutions and continents in the vain hope that an exceptional loss incurred by, say, a broker in Bombay could help 'fatten the tail' of an operational loss distribution for an asset manager in Manhattan. Of course, there are always things to learn from the past – one might even argue that there is nothing else to learn from – but the mere recording of a loss amount in one firm cannot be translated mechanically into a probability and severity of loss in another firm. On the other hand, the anecdotal evidence about the way disasters occurred (or were avoided – there must be more near disasters than actual disasters and therefore more to learn from them) and the way they were handled may be very informative; it may stimulate thoughts and help discover vulnerabilities in one's organisation and therefore identify potential problems to be examined; that is a lot, but that is all.

The second ghost is the belief that extreme value theory (EVT), a branch of probability theory and statistics, can make an important contribution to the assessment of exceptional operational risks. EVT was developed many years ago to describe the distribution of extreme values in repetitive processes [15]. In mathematical term, it is possible to describe the probability distribution of the maximum value (or the distribution of excess over threshold) in a set of observations of identically and independently distributed random variables (i.i.d), based on a few assumptions about the underlying distribution (about its tail in particular). Thus, Gumbel produced estimates of the floods of the Colorado River based on many years of observations of river flows at Black Canyon. In general, EVT has been successful at describing extremes of physical processes where a theory gives some indication about the underlying distribution and the observations are i.i.d. More recently EVT has been applied with some success in finance (maximum variations of the stock market) and insurance

[15] See for example: Gumbel, E.J, *Statistics of Extremes*, Columbia University Press, New York, 1958 and Embrechts, P., C. Kluppelberg and T. Mikosch, Modeling Extremal Events, Springer Verlag, Berlin, 1991

(estimation of extreme losses of a given type) under similar circumstances. But to try to apply EVT to a small set of unrelated operational losses in different firms around the globe is another triumph of wishful thinking over reason. At best, it could be used to study the extreme severities in one category of what we called ordinary operational risks, provided losses have been observed many times and may be assumed (perhaps after recalibration) to follow the same distribution.

A poor cousin of the EVT ghost has also been spotted around financial institutions, often in the company of management consultants; we shall call him the extreme value simulation ghost, or EVS for short. The EVS ghost proceeds like this. Start with a large external operational losses database that contains all sorts of loss events. Screen out the events that obviously could not occur in the firm under review; e.g., no rogue trader losses in a firm not involved in trading. Somehow, scale the severities of the remaining events to the relative size of the firm (perhaps by looking at relative size and number of transactions). Also scale the number of loss events to one year for the relevant firm. For example, if there are N loss events remaining in the revised database contributed over Y years by banks with an adjusted[16] total capital C whereas the capital of the target firm is c, the expected equivalent number of loss events during one year for the target firm could be assessed as $E(n) = Nc/(CY)$. The penultimate step is now to pick at random n loss events among the N events in the database, where n is a random variable (perhaps Poisson distributed) with mean E(n). The sum of all n losses gives a realisation of what could be operational losses for the target firm over one year. The final step is to repeat the sampling exercise 10,000 or perhaps 100,000 or a million times (computers are fast and cheap) to create a histogram of losses with about 10 occurrences (100 or 1000 respectively) beyond the 99.9% quantile, thus yielding an estimate of losses at that confidence level. The whole process can be obfuscated with enough technical jargon to make it look scientific and justify a high fee.

What's wrong with EVS? Aside from all the difficulties in trying to make external data relevant for a specific firm, the main problem is confusing the observation of a few rare loss events with a model for extreme losses. As we have discussed, the extreme tail, or 99.9% quantile, of an operational loss distribution is dominated by the possibility of a few very large impact but very improbable losses. The largest industry-wide databases will still contain just a few examples of these exceptional losses and therefore can only lead to highly unreliable estimates of their probabilities. For example, if 5 loss events of a certain type are observed in a 5,000 firm-years database, should the probability of occurrence of such events in one firm over the next year be estimated at one in a thousand? Statistics tell us that the probability of occurrence could very well be twice as small or twice as big. And what about the probability of several of these events happening in one year? How small? We do not have much of an idea unless we examine these events in detail. Perhaps if one happens now it cannot happen again for several years or precludes others from happening. Or, at the other extreme, the occurrence of one may greatly increase that of others as in a chain reaction[17]. All that, which is crucial, is overlooked by EVS. It is a blind approach.

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[16] Capital corresponding only to relevant activities of the target bank

[17] I heard Prof. R Howard of Stanford University, whom many regard as the father of modern decision analysis, give this vivid illustration of a combination of rare events. Suppose your company has invested in the biggest most luxurious, most state of the art and safest ocean liner in history and you want to assess the main risks for this ship that will cruise the North Atlantic route. Historical records will show damages or complete loss of ships due to heavy seas, collisions with other ships or icebergs, fires, mechanical problems, etc. Loss severities depend on the preparedness of the crew, the availability of lifeboats, communications, proximity to other ships etc. A consultant might well have used these data and, after scaling and numerous simulations, come up with a loss distribution and an estimate of the 99.9% quantile. The ship was the Titanic and we know what happened during her

An Exceptional Operational Risk Case Study

Is there a general methodology that can be devised to analyse rare but important operational risks? I do not think that there is a single approach or mathematical technique, but there are a couple of features that must be recognized and addressed in any meaningful approach. The first is the need for models to assess low probabilities; the second is the need for a quantitative tradeoff between profit (or cost) and uncertainty, i.e., an expression of risk attitude, to enable a rational choice among alternative courses of action to deal with exceptional risks. Courses of action span a range from risk retention, perhaps combined with additional safety measures, to partial or total risk transfer (insurance, outsourcing). In the spirit of the previous comments about the nature of exceptional risks we illustrate a general approach by looking at a new type of man-made threat – a computer super-virus that could affect an e-banking venture.

An E-banking Venture

A leading bank plans to gain market share through an e-banking subsidiary. Considerable efforts have been put into ensuring the reliability and client safety of the systems: multi-key authentication, encrypted communications, transmission firewalls, systems redundancy including distributed processing and multiple data storage centers, disaster recovery sites, etc. But is there any protection against a mad individual bent on creating havoc for whatever reason? Alas, brilliant but twisted minds are not rare.

We know how rapidly a known organic virus can spread and how difficult it may be to control, viz. the recent foot-and-mouth epidemic in Great Britain. The consequences of more potent, perhaps yet unknown, viruses could be devastating. Computer viruses can also be very potent. Designed by man, they can be very infectious[18]; they can have a very long 'incubation' period during which they spread undetected. They can be designed to break down safety mechanisms, to reveal confidential information that will permit fraud, to wipe out critical information on a broad scale and to render systems unusable for a time. Like meteorites, they are not uncommon. Thousands have been detected and dealt with by specialist companies before they could spread too far and create huge damages. Yet, one day, one could have devastating consequences.

To assess the probability of a computer virus infection and its potential damages, a detailed map of the systems hardware and software will be studied by experts looking at possible entry points for the virus, deciding where should be the main firewalls, which tests, where and at what frequencies should be carried out, what recovery strategy should be put in place depending on the extent and severity of the infection. Many decisions will require trade offs between safety and costs or convenience. For example, should a time consuming virus check

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maiden voyage. The unique combination of rare circumstances during this fateful crossing – wanting to regain the blue ribbon and therefore progressing at maximum speed along the shortest route, further North than normal; ship more than full with passengers, much festivities on board, minimum watch, incredulity at first about the scale of the accident and slow reaction time, lack of life saving equipment and unavailability of some because of heavy listing, etc., etc – makes the historical data largely irrelevant. Vice versa, much more can be learned about this disaster for future safety management than from the mere recording of one major loss event.

[18] Viruses have been transmitted by simple emails without the recipient having to open any file or simply by accessing an Internet service.

be carried out every time a connection is established with a client? Should backups of all communications and transactions be kept in various remote places? What resources should be arranged on a standby basis to recreate lost or corrupted records? In the terms and conditions for opening accounts, which liabilities will the bank be prepared to accept and which will they decline; should a guarantee on client moneys be provided by the parent bank? Could part or nearly all the operations be outsourced to a major IT company that would bear the main responsibility in case of a virus attack? Could the bank purchase insurance to cover at least some of the risks?

It would be all too easy to lose sight of the essential when studying such complex situations. A team of experts without management guidance would be no better than a patrol of ants trying to make sense of a Pollock painting by running all over it. Good managers and decision analysts have found from experience two semi-universal laws:

(i) Experts will often get lost in details and be overconfident about their state of knowledge; after all, they are being paid to know. Thus systems analyses will include a vast number of variables but scenarios about what may happen will be confined to rather narrow, uninventive ranges.
(ii) Decision situations, no matter how complex at first sight, are generally dominated by just a few critical factors, be they dominant sources of uncertainty or key decision variables. The art of decision making is to identify these factors and focus the analysis on them.

Critical factors are identified step by step by refining a model and assessing consequences iteratively. The decision situation can be depicted with the help of an influence diagramme (see 7.3.4): some nodes represent choices between alternatives (decision variables), others sources of uncertainty (state variables); terminal nodes reflect states of the systems to which values can be attributed. The connections leading to terminal nodes represent the interactions between decisions and external factors leading to various terminal states of the systems with corresponding probabilities. One starts with a simple representation and conducts sensitivity analyses. Unimportant state variables are set at fixed values; unimportant decision are simplified or predetermined. But the most influential factors are subjected to further investigations: additional information is sought where economically justified; large uncertainties are described with full distributions; major alternatives are refined. This type of approach has been used in a number of industries to analyse complex systems and assess reliability and safety standards where the probabilities of failure or accidents are extremely small.[19]

Proceeding along these lines but without further details, suppose the e-banking venture has been summarized to a choice between two main strategies:

(i) **Standard Safety –** All measures are put in place to protect against known strains of computer viruses and new strains as they are discovered. The business plan, taking into account the initial investment and projections of revenues and operating costs over the effective life of the venture, indicates an €800 million expected net present value in the absence of any super-virus attack but a loss of €400 million if a super-virus strikes. The probability of the latter event is perceived at around 5%. Of course there are enormous uncertainties around all of these figures. These are indicated in Table 6
(ii) **Enhanced Safety** – Extra precautions are taken which will not only increase the initial investment and the operating costs but are also expected to reduce market share because

[19] Probabilities of failure with ensuing fatalities can typically be set at one in a million to one in 100 million per year or per mission.

the services will be less user friendly. Consequently, the net present value of the venture is lower than under the Standard Safety plan but the probability of a super bug attack is reduced to about 0.5% and the consequences (e.g., reputational effects) are also mitigated. The key figures for the two alternatives are reported in Table 6

Table 6: E-banking Alternative Strategies

Strategy	**Standard Safety**	**Enhanced Safety**
Probability of super bug strike	5%	0.5%
Net present value if no strike	€800 ± 200 million	€500 ± 200 million
Net present value if strike	-€400± 200 million	-€350 ± 150 million

A few comments are in order:

1 There is no hiding the difficulty of reducing a choice of strategies to simple terms. All outcomes must be reduced to monetary values. Future cash flows must be expressed at a present value using some discount factor (normally the minimum return on capital required by the parent bank). Uncertainties must be assessed and aggregated. The relative importance of various choices must be ascertained to identify the few most critical.

2 The probabilities of a super bug strike during the effective life of the venture (i.e., many years) would be most difficult to assess. The views of experts could span wide ranges; for example, 5% for the Standard Safety strategy could mean somewhere between 2% and 10%. But, interestingly, we shall see that uncertainty about such probabilities should not be a major concern; that is why no uncertainty range for the probability of a super bug strike has been shown in Table 4.7

3 The losses in case of a strike are larger for the Standard than for the Enhanced Safety Strategy for several reasons. First, the venture being a limited liability company, direct losses to the parent company cannot be larger than the capital they have invested in the venture, which capital may be larger for the Standard Safety strategy because of greater operational risk capital requirements. Second, whatever the legal limitations to the liability of the parent bank, there will be reputational damages and these will be more limited if the parent bank can show that exceptional precautions had been taken. Third, the Enhanced Safety strategy can be thought as having additional mechanisms in place to contain the severity of the damages. The results we show in case of a super-virus attack mean that the initial investment of the parent bank would be wiped out and there are additional but uncertain reputational losses. In other words, the losses to the parent bank attributable to the super-virus are perceived as €1200 ± 200 million under the Standard Safety strategy and €850 ± 150 million under the Enhanced Safety strategy.

Now let us compare the two alternatives. On an expected value basis, the Standard Safety strategy is a clear winner with an expected value of €740 million against €496 million for the Enhanced Safety strategy[20]. But that ignores the risks and the directors of the parent bank may have different opinions about the right choice, indeed they are all entitled and expected to defend their own views; still a decision must be reached.

Quantification of Risk Attitude

[20] The expected values are: (i) for the Standard Safety strategy 95%(800) – 5%(400) = 740 and (ii) for the Enhanced Safety strategy 99.5%(500) – 0.5%(350) = 495.75

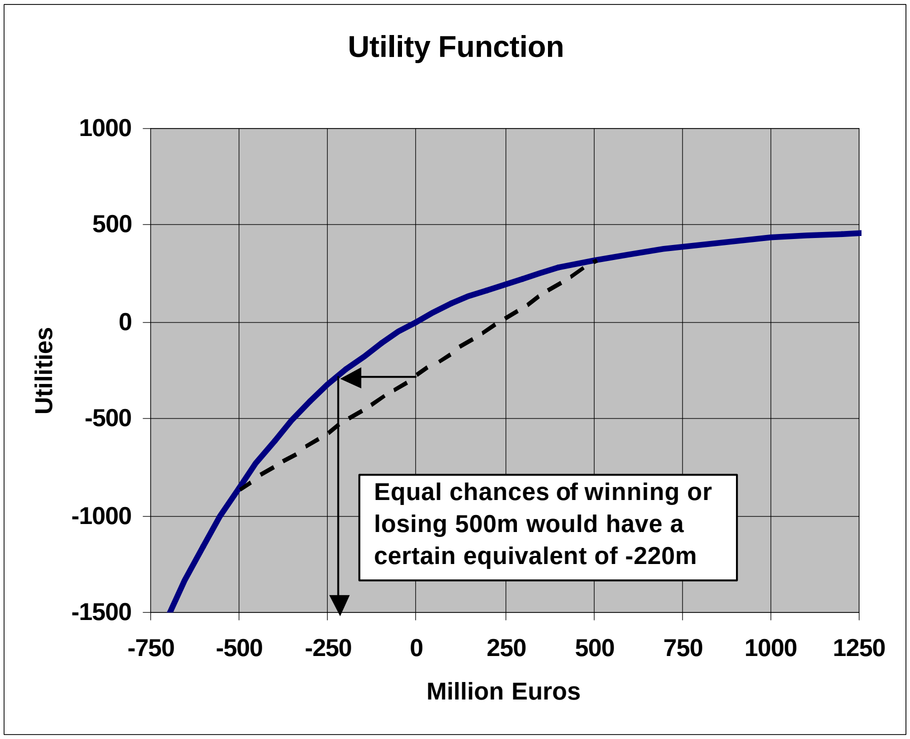
Each situation where risks play a determinant role could be decided on a case by case basis, perhaps on a majority vote, and that is indeed how many important business decisions are taken. At the same time, there should be some feeling of uneasiness about the subjective nature of this decision process. One should like to ensure a minimum degree of consistency across successive decisions. It would not make sense if, say depending on the mood of the moment, the decisions were wildly fluctuating over time from risk averse to risk taking. Likewise, it would not make sense if some opportunities were deemed to be too risky for one division but desirable for another. The firm could be arbitraged, that is, one could imagine a hypothetical third party being paid to take away opportunities that are too risky from one division only to sell them at a profit to another division.

It would be much more satisfactory if risky opportunities could be summarized in a systematic way by just one number, something like a minimum selling price, that would encapsulate the degree of risk aversion of a firm. Intuitively, the degree of risk aversion or trade-off between risks and rewards ought to be relatively stable. It should evolve over time with the accumulated results of the firm but only progressively and, at any point in time, there should be only one local trade-off otherwise, as we mentioned earlier, the firm could be vulnerable to arbitrage.

Fortunately, the methodology exists; it has been developed more than 50 years ago and is known as utility theory[21]. The fact that it is not widely used has more to do with conflicts between personal interests of decision makers and the good of a company – a subject far beyond the scope of this chapter – than to any flaw in the theory. The concept is simple and based on just a few basic rules of behaviour that no businessman would knowingly want to violate. A utility theory primer is given in the Appendix to this chapter. We shall assume for the rest of this discussion that the parent bank, as part of its risk management framework, has chosen to describe its risk attitude with the utility function represented in Figure 2.

[21] Utility theory was developed in 1947 by the mathematician John von Neumann and the economist Oskar Morgenstern.

Figure 2: Risk Attitude of Parent bank



Firm
s that have gone through the effort of drawing a utility function are generally satisfied with an exponential fit, i.e., a function of the form

$$u(x) = \lambda(1 - \exp(-x/\lambda)$$

where the parameter λ, called coefficient of risk tolerance is in the range of 10% to 20% of the capital of the firm. To clarify the evaluations in our case study, we shall assume that the parent bank has capital of the order of €3 billion, and adopts an exponential utility function with a coefficient of risk tolerance of €500 million. That is the utility curve actually plotted in Figure 2.

Choice of Strategy, Value of Information and Value of Insurance

(a) The best strategic choice as a function of risk attitude

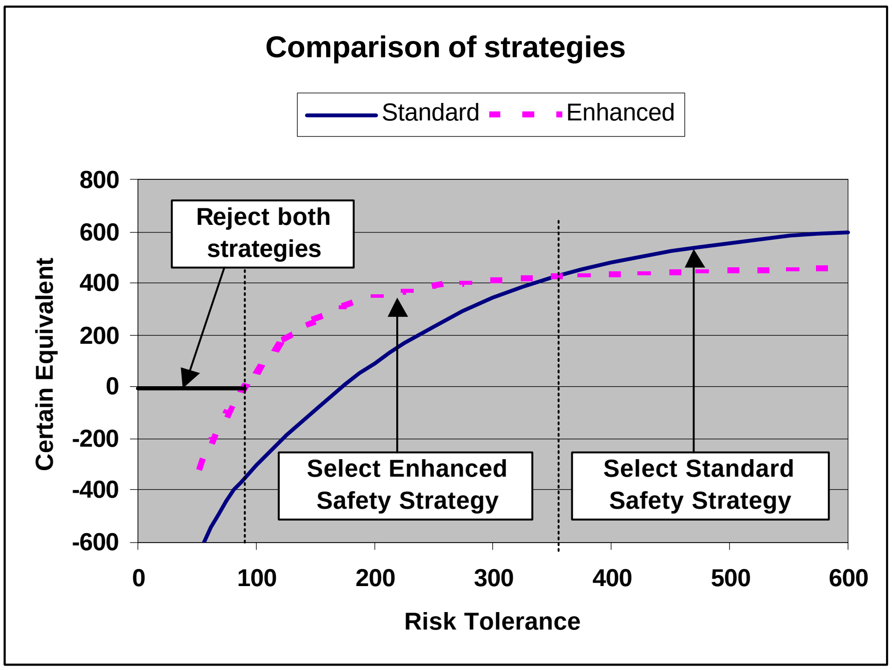
The two alternative strategies, Standard and Enhanced Safety, are far from yielding normally distributed outcomes, so it would be inaccurate to use the mean/variance approximation of the certain equivalent. We therefore carry out exact calculations of the certain equivalent for each strategy but we assume, for simplicity that the main risks of the e-banking venture are independent from the existing risks of the parent bank. The results, together with the expected values, are shown in Table 7

Table 7: Choice Criteria for E-banking Strategies

Strategy	Standard Safety	Enhanced Safety
Expected value	€740 million	€496 million
Certain Equivalent (λ = €500m)	€557 million	€449 million

With the €500m level of risk tolerance the decision should be clearly in favour of the Standard Safety alternative; it is worth €108m more than the Enhanced Safety alternative. But given that the €500m level of risk tolerance is rather an order of magnitude than a precise figure, it would be interesting to know at what level of risk tolerance the decision could shift in favour of the Enhanced Safety alternative or perhaps even in favour of abandoning both alternatives because they would be deemed too risky. To that end we calculate the certain equivalent of both alternatives over a wide range of risk tolerance coefficients. The results are plotted in Figure 3.

Figure 3: Certain Equivalent of E-banking Strategies



The evaluations show that as long as the coefficient of risk tolerance is above €350m, the Standard Safety strategy is the preferred option. For a risk tolerance between €350m and €90m, the Enhanced Safety strategy is better. But if the risk tolerance of the parent bank were below €90m, none of the two e-banking proposals would be acceptable, even the Enhanced Safety strategy would be perceived as too risky.

(b) The value of Additional Information/Analysis

There is a great simplifying virtue in focusing an analysis on decisions that matter. A situation like the choice of e-banking strategies that we have just considered is fraught with complexities and uncertainties but it is not necessary to study every detail to reach rational decisions. For example, we have just seen that it is not necessary to pin down very precisely the risk attitude of the parent bank to choose between the two key safety strategies. Having made this key choice, one can proceed to refine the chosen strategy and worry less about risk tolerance.

Another example would be the value of ascertaining with greater confidence the probability of a super-virus strike during the effective life of the venture. We commented earlier that such probabilities are difficult to assess; given half a chance, experts will disagree! But we also said that uncertainty about a low probability event is not so important. The reason should be clear now – the expected utility criterion is nearly linear in the probability of rare events, therefore an average probability will do. Of course it may matter whether the average, or best guess is, say for the Standard Safety strategy, 5% as we have assumed, or 3%, or 7%; that can be tested.

By re-calculating the certain equivalent with higher probabilities of super-virus strikes, we would find that, at the €500m risk tolerance level, the probability of a strike would have to be greater than 8.5% under the Standard Safety strategy to justify switching to the Enhanced Safety strategy. Refining the analysis of the probability of a strike to improve its accuracy would add costs and delays. It would not be worthwhile, because it would not affect the key strategic decision, unless there is a chance that the findings could lead to a probability estimate larger than 8.5%. Thus the value of refining the analysis depends on the uncertainty shrouding the initial estimate, the improvement in accuracy expected from further studies and, of course, the risk attitude of the company. In the current situation with a coefficient of risk tolerance of €500m, further studies of the strike probability would not be worth very much as they would be unlikely to lead to an improved decision. By contrast, if the coefficient of risk tolerance was only €350m, we would not be sure which of the two strategies is best and better information on the probability of a strike would help select the best alternative; better information would be quite valuable[22].

Displaying the domains of parameter values over which one strategy is better than another requires more calculations but helps identify critical parameters and reduces the task of assessing their values to judging in which ranges they are. This approach is often referred to as the extensive form of decision analysis.

(c) The Value of Insurance and Risk Sharing

Finally, armed with a quantitative statement of risk attitude, we can address in the same consistent way a number of other decisions where uncertainty matters. The process of encoding risk attitude into a utility function would be hardly worthwhile if only one critical decision had to be analysed, but it is likely that a firm would like to examine a number of problems, be they exceptional operational or business risks, with the same tool. To illustrate, consider the general problem of sharing or totally transferring some risks through insurance.

[22] As 'back-of-the-envelope' calculation, suppose that the initial estimate of 5% strike probability has an uncertainty represented by a normal distribution with standard deviation s1; a refined analysis could reduce the uncertainty to s2 (s2<s1). With a €350m risk tolerance both strategies have about the same value (certain equivalent) of €425m. But the value of the Standard Safety strategy decreases by €38m per percentage point increase in the probability of a strike. Perfect information would leads us to chooses the Enhanced Safety strategy if the probability of a strike turned out to be greater than 5%, a saving of €38m per percentage point above 5%, that is, an expected saving equal to the value of a call at 5% on the probability of a strike at €38m per point. Perfect information would be worth about (0.4)(38)s1; e.g., €22.8m if s1 were equal to 1.5%. But perfect information may remain a dream; if the residual uncertainty is s2>0, the information would still be worth (0.4)(38)(s1-s2); e.g., €7.6m if s2=1% and s1=1.5%.

There are many reasons why firms, like individuals, buy insurance – force of habit, convenience, sometimes legal requirements – but fundamentally it should be based on economic reasons. The value of the insured risk net of insurance premium should be greater than the value of the uninsured risk. Within our valuation framework, for value, read certain equivalent. We complete our case study of e-banking by estimating what would be the value of insuring the venture against a super-virus.

For the sake of simplicity, we confine our analysis to the maximum value of an insurance that would provide a 100% cover all economic consequences related to a super-virus strike and nothing else[23]. This is the maximum value we would be prepared to pay for a single, front-end premium; knowing this value would help decide whether various insurance proposals could be attractive. The calculation of the maximum insurance premium P would in general be iterative, that is, we would have to solve the equation

Certain Equivalent (insured strategy – P) = Certain Equivalent (non-insured strategy)

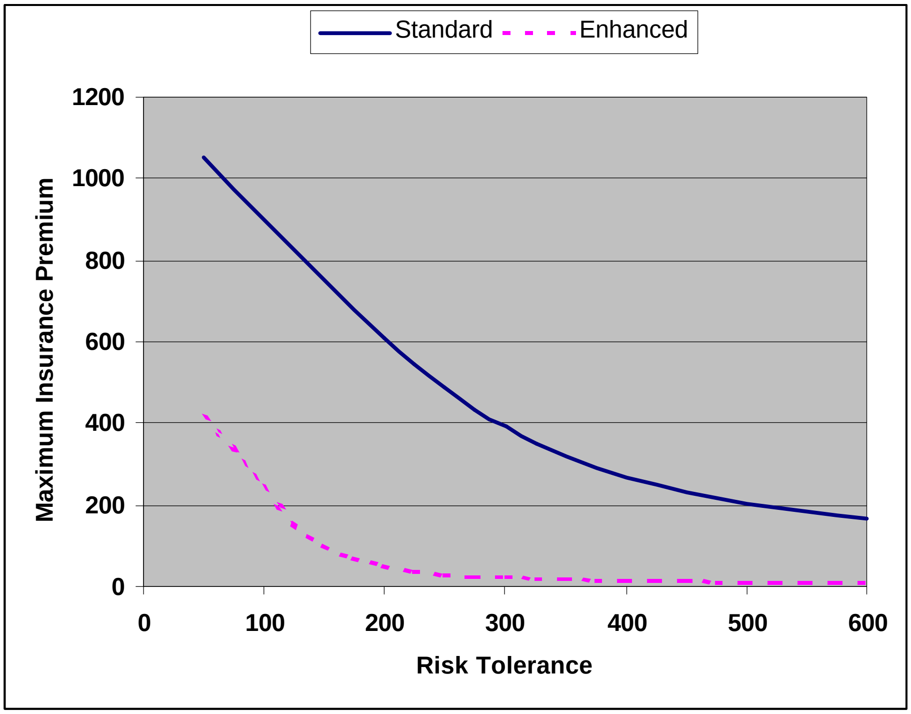
by searching over P. With the exponential utility function we have chosen, the solution for P can be directly obtained since

Certain Equivalent (insured strategy – P) = Certain Equivalent (insured strategy) – P

The maximum economic insurance premium for both strategies is shown in Figure 4 over a wide range of risk tolerance. Not surprisingly, it is much higher for the Standard Safety strategy, which is more vulnerable to a super-virus, than for the Enhanced Safety strategy. For both strategies, the maximum economic premium decreases with increasing levels of risk tolerance but remains always larger than the expected loss being covered. The expected losses due to a super-virus are easy to calculate: for the Standard Safety strategy it is €60m (= 5%(800 - (-400)) and for the Enhanced Safety strategy only €4.25m (= 0.5%(500 - (-350)). For example, at the €500m risk tolerance level the maximum economic insurance premia would be €203m for the Standard Safety strategy and €11m for the Enhanced Safety strategy. These figures are markedly larger than the respective expected losses, leaving room for a profit margin and a risk premium for the would be insurer.

[23] Note that we do not address here the possible effect that the existence of an insurance contract could have on the potential claim amount. We alluded earlier to the fact that the total capital invested in the company would put a limit on the maximum amount of losses to the parent. The existence of an insurance contract could lift up this limit unless an equivalent maximum loss amount was stated in the contract. But then the venture, and therefore the parent company, could still make excess losses and that would make the cover less valuable. On the other hand, the existence of an insurance contract could justify a reduction of the regulatory capital of the e-banking venture, thus making the insurance contract more valuable. Without pretending that the two effects would cancel each other, we shall ignore these thorny issues for the sake of simplicity. In a real life situation, the proposed methodology could be readily extended to cover such issues.

Figure 4: Economic Value of Insurance to the Parent Bank



But is it likely indeed that insurance could be obtained at a lower cost than its maximum value? Why should an insurance company be in a better position than the parent bank to absorb the potential losses? We can apply the same methodology to calculate the minimum premium that an insurance company would be willing to accept.

Covering the e-banking venture designed under the Standard Safety strategy against the risk of a super-virus attack could cost an insurance company a net present value of €1200m with an uncertainty of €283m if a strike took place; at least, that is what the parent company would think based on their analysis. The €283m uncertainty is the uncertainty between the gains without the virus and the losses with the virus, two independent uncertainties of €200m each for the insurance company[24]. The corresponding figures for the Enhanced Safety strategy would be €850m with an uncertainty of €250m (combining independent uncertainties of €200m and €150m). Of course, the insurer could carry out a different analysis with different estimates and parameters but for the time being lets assume that the insurer and the parent bank agree on the risks.

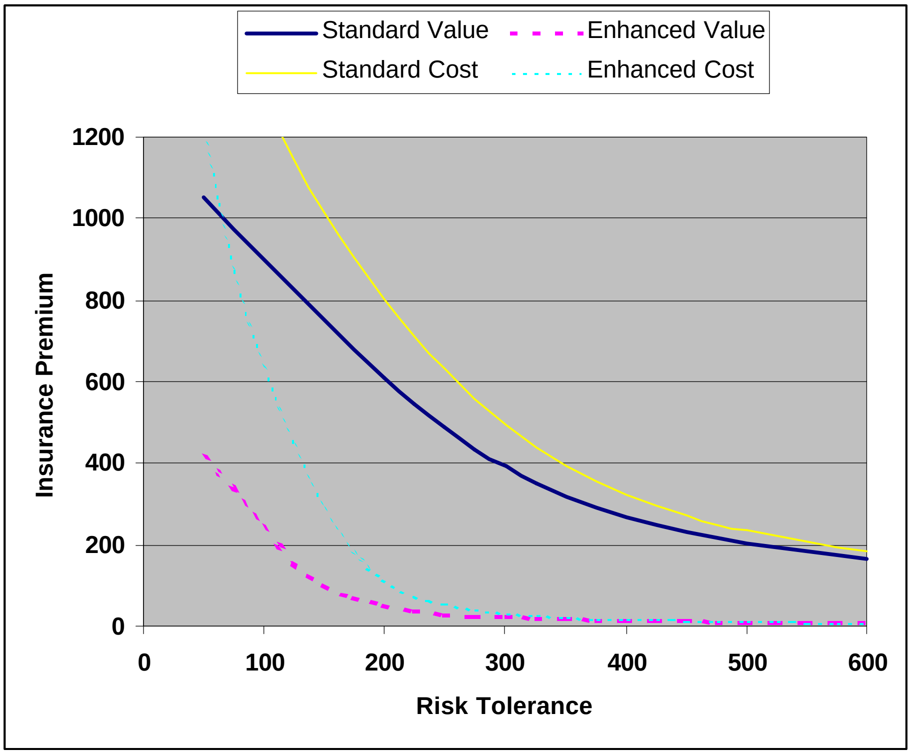
As compensation the insurer would receive a front-end premium Q. What should be the minimum economic value of Q? If we pursue a similar analysis of the certain equivalent of the insurance contract for the insurer, the minimum premium value would solve:

$$\text{Certain Equivalent } (Q - \text{Liabilities}) = 0$$

[24] For the parent company these two uncertainties are not independent. The losses in case of a virus attack that would bankrupt the venture are larger if the profits before the attack were larger themselves.

Given that the liabilities for the insurer have the same expected value but a greater uncertainty than the corresponding risk reduction for the parent bank, for equal levels of risk attitude, it is clear that there would be no possible insurance deal. The minimum premium requested by the insurer would exceed the maximum premium that the parent bank would be willing to pay. Figure 5 below, confirms this point by comparing the maximum value of the insurance cover (as in Figure 4) with the minimum cost of the cover to the insurer for various levels of risk tolerance.

Figure 5: Maximum Economic Value versus Minimum Economic Cost of Insurance



For example, the figures for the base case €500m risk tolerance level are:

Table 8: Comparison of Acceptable Insurance Premia for Insurer and Insured with the same €500m Risk Tolerance Coefficient

Insurance Premium	Standard Safety	Enhanced Safety
Maximum value to the bank	€203 million	€11 million
Minimum cost to the insurer	€234 million	€13 million

Under what circumstances would insurance become economically viable (leaving aside patent errors or accounting and regulatory distortions)? Our analysis reveals three situations that could justify an insurance cover:

1. The transferred risk provides more diversification (or hedging) to the insurer than to the insured
2. The insurance company has a greater coefficient of risk tolerance than the insured, possibly because it has a much larger capital.
3. A partial insurance cover is considered

The first situation is the reverse of what we observed in our case study and which caused the excess of cost over value. It may occur if a bank wishes to insure some of several positively correlated risks and, on the other hand, the insurance company seeks to diversify its risks[25].

The second situation can be found either when large insurance companies insure small clients or when the risk of a large client is shared with large reinsurers. Otherwise, if insurer and insured are similarly capitalized there is no obvious reason why the insurer should adopt a more risk taking attitude. For large risks the insured would simply exchange a business risk against a credit risk on the insurer, a factor that should be taken into account in the analysis of the value of the insurance contract.

The third situation is particularly interesting because of its general applicability. One should note that any risky opportunity with a positive expected value is worth sharing in, no matter how risk averse one may be[26]. In the case of exponential utility functions it can be shown that the optimal sharing in a risky opportunity among various interested parties, that is the allocation that maximizes total expected utility, is in proportion to the coefficient of risk tolerance of each party. Even small insurers can therefore insure big banks provided they cover only a small fraction of the risks.

Conclusions

We live more and more in a culture of caution where the 'ownership' of risks is assigned to individuals who may have a limited understanding of global objectives or, at any rate, are given limited responsibilities and personal incentives. Thus, in some schools, little girls are no longer allowed to skip ropes or make daisy chains because they might get hurt or transmit diseases.

We should have a similar concern that by institutionalising a risk management function in financial firms and creating separate departments with responsibilities restricted to specific types of risks – as if these risks could be treated separately and independently of the economics of the main business activities – we may be creating an environment that is not conducive to good management.

A balance has to be found between the need, on one hand, to develop specific risk analysis skills and to have independent reviews of the risk management process and, on the other hand, the need to integrate all the elements that are necessary to reach intelligent decisions balancing risks and rewards.

[25] Major insurance disaster have been caused more often by small but highly correlated losses (e.g., asbestos or collapse in residual value of leased computers) than by major single losses which are normally shared through reinsurance.

[26] In footnote (23) we show that the risk discount D varies proportionally to the variance of a risky project and therefore proportionally to the square of the share in that prospect, whereas the expected value varies proportionally to the share itself. Therefore, when the share is decreased, at some point the risk discount is bound to become smaller than the expected value of the small share.

Finding the right balance is particularly relevant when considering operational risks. It would be naïve to assume that operational risks must be minimized – that unlike credit and market risks, which must be accepted to some degree in order to generate a profit, operational risks should be eliminated as far as possible[27]. The main difference between operational, credit and market risks is that the last two can be manipulated by adding or taking away risks at market price, i.e., without affecting the current fair value of the activity (except for transaction costs), whereas operational risks can only be altered at a cost, hence the importance of taking expenses and revenues into account.

We argued that the framework for operational risk management should be focused on improving decision, that is on evaluating alternatives to the status quo, taking into account all major consequences rather than just the impact on operational risks. It is all very well to collect operational loss data and to monitor so-called Key-Risk-Indicators (KRI) and Key-Risk-Drivers (KRD) but unless KRDs are clearly defined as decision variables and all consequences of these decisions, not only their effects on KRIs or even on operational losses, are taken into account, no progress towards better management will be made.

To carry out a decision focused approach, we found that it would be useful to distinguish various types of operational risks based on the relative importance of uncertainties compared to expected losses.

Routine risks, that is, operational loss events that may occur once a week or more frequently, are at the very low end of the uncertainty scale; it is expected losses, both direct and indirect (reputation) and impact on costs and revenues that count. Bankers could learn a lot from the discipline of Total Quality Management that has been applied very successfully in other industries, to manage *nominal operational risks.*

We called *ordinary* risks those operational loss events that would happen less frequently than once a week and could be as rare as once every few years. Both the uncertainties and the expected losses generated by ordinary risks are significant. It is crucial is to assess the relationships between these risks and other risks to obtain a comprehensive picture of risks and rewards.

We signaled out as *extraordinary* risks operational loss events that are very unlikely (say 2% or less probability of occurrence per year) but would have devastating effects if they occurred. There again it is important to establish how these risks would interact with others, but one new ingredient, the risk attitude of the firm, becomes paramount for choosing the best risk control method (risk mitigation, insurance, outsourcing, etc.). Many financial institutions and, indeed, regulators talk about risk appetite or similar expressions, but very few have gone as far as quantifying this concept to make it useful for decision making. Perhaps banks should be urged to do so.

[27] It is interesting to note that in the revised draft on Sound Practices [4], Basel kept the statement (p4) "… it is clear that operational risk differ from other banking risks in that it is typically not taken in return for an expected reward…" but adds in a footnote "However, the Committee recognizes that in some business lines … the decision to incur operational risk, or compete based on the ability to manage and effectively price this risk, is an integral part of the bank's risk/reward calculus."

References:

[1] Howard, R., 2000, ”Decisions in the face of Uncertainty”, in *Visions of Risk*, ed. C. Alexander, Financial Times – Prentice Hall

[2] Howard, R., Matheson, J.,(eds), 1984, “The Principles and Applications of Decision Analysis, Vols 1 & 2 ”, Strategic Decision Group, Menlo Park, California

[3] The Quantitative Impact Study for Operational Risk: Overview of Individual Loss Data and Lessons Learned from the Risk management Group of the Basle Committee on Banking Supervision, January 2002

[4] Sound Practices for the Management and Supervision of Operational Risk, the Basel Committee on Banking Supervision, December 2001, revised July 2002

Note: all publications from the Basel Committee are available on the Bank for International Settlements’ website, www.bis.org.

Appendix: Utility Theory

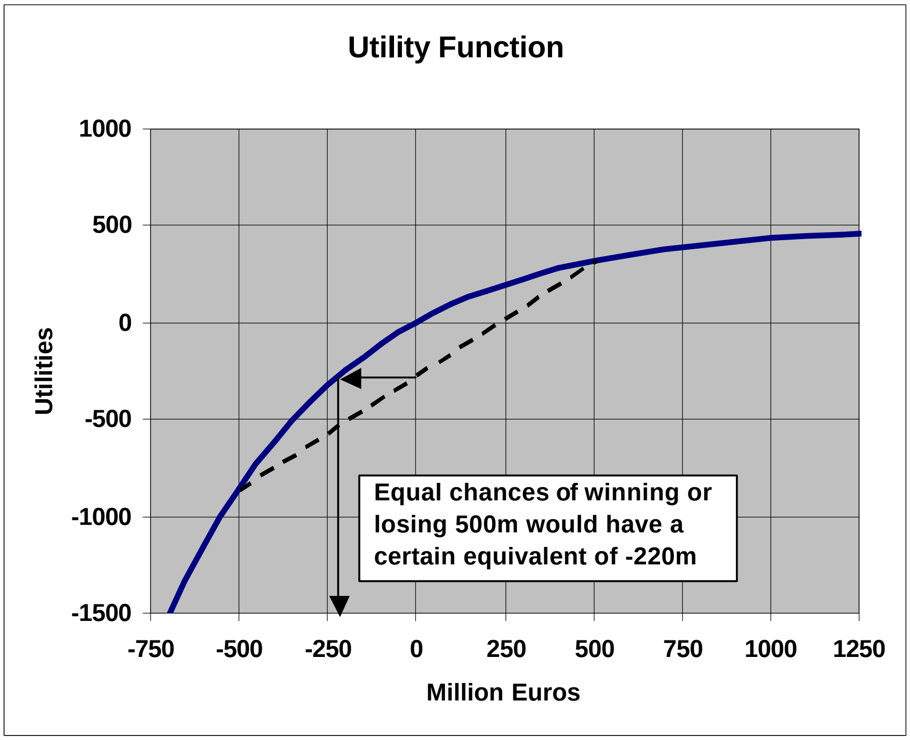
Utility theory, as developed by J. von Neumann and O. Morgenstern, rests on only three behavioural assumptions: (1) all outcomes of the decisions under examination can be ranked in order of preference; that is, if among three outcomes A, B and C, we strictly prefer A to B and B to C then we ought to strictly prefer A to C; (2) if, as in (1), we strictly preferred A to B and B to C, then for some probability p, we should be indifferent between receiving B for sure or having a probability p of receiving A and (1-p) of receiving C; (3) Among two risky opportunities offering the same possible outcomes, we ought to prefer the opportunity presenting the larger probability of obtaining the preferred outcome

Few decision makers would refuse to accept these rules. Indeed, if they were shown to violate any of these rules, they would probably want to modify their behaviour to conform to these rules.

The powerful consequence of these simple rules is that matters of choice between risky opportunities can be resolved by attributing a utility value to each outcome and calculating the expected utility of each opportunity. The opportunity with the maximum expected utility ought to be preferred over the others.

Assigning utilities to possible outcomes is the critical step to which we will come back shortly. But let us remark first that, for financial decisions, outcomes will already be measured on a monetary scale. Utilities will therefore form a continuous, non-decreasing function (because we can be trusted to prefer always a bit more money to less) over a range of possible monetary outcomes as illustrated below.

Describing risk attitude with a utility function



It is the curvature of this function that captures the degree of risk attitude of the firm. A downward expresses a certain degree of risk aversion[28]; the minimum selling price of a risky opportunity shall be less than its expected value. For example, faced with a risk of winning or losing €500m with equal probabilities, the firm with the utility function above would perceive an expected utility of about –270; that has the same utility as a sure loss of €220m. In other words, the firm would be willing to pay someone €220m to take the risk away. The sure quantity equivalent to a risky prospect, i.e., its minimum selling price, is often referred to as its *certain equivalent*. Choosing the alternative with the maximum expected utility amounts to choosing the alternative with the maximum certain equivalent.

Drawing a utility function for a firm is a tricky exercise best conducted by an experienced outsider. A few points along the curve can be inferred from choices directors and executives would agree to make among simple risky prospects. The results would probably form an elongated cluster of points rather than a smooth monotonic function, but precision is not all

[28] Consider a risky prospect X with expected value E(X) and variance Var(X), and a utility curve u(x). From the first couple of terms of a Taylor series expansion of u(x) at the expected value E(X) we obtain: $E(u(x)) = u(E(X)) + 1/2\, u''(E(X))Var(X)$. Equating this to the utility of E(X) – D, where D stands for a the risk discount, which we approximate with $u(E(X)) - D\, u'(E(X))$, we obtain the approximate risk discount value $D = -1/2\, (u''/u')\, Var(X)$ which shows that the risk discount is proportional to both the local curvature of the utility curve u''/u' at E(X) and the variance of the risky prospect.

that important and a free hand curve drawn through a first set of points will be a good start for further debates.

To ensure a smooth function (i.e., without sharp kinks as it often happens on first assessment) one can try to fit a known functional form, for example, an exponential, a logarithmic or a power curve. An ancillary benefit is that a simple functional form (defined within a positive linear transformation[29]) can be summarized by one curvature parameter.

For example, a firm could adopt an exponential utility curve. Parameterised as

$$u(x) = \lambda(1 - \exp(-x/\lambda)$$

utilities are nearly equal to monetary values for small amounts ($x << \lambda$); parameter λ is directly related to the curvature[30] and describes the degree of risk tolerance of the firm. For large λ the utility function becomes almost linear, that is the firm would be risk neutral, whereas for small λ the firm would be risk averse. The exponential utility curve has a few interesting properties that may appeal. For example, if a sure quantity (positive or negative) is added to all outcomes, the certain equivalent is modified by that quantity. Therefore there is no need to define an absolute zero on the outcome scale; the same exponential utility function can be used for different decisions simultaneously or over time (provided that correlations between risks are taken into account).

If the outcome variable X is normally distributed with expected value E(X) and variance Var(X) the certain equivalent with an exponential utility is:

$$CE = E(X) -(1/2\lambda)\ Var(X)$$

that is, the maximum expected utility (or maximum certain equivalent) criterion reduces to a mean/variance criterion in which the trade off between expected value and risk (measured by a variance) is directly related to the coefficient of risk tolerance λ.

This property can used to obtain an approximate but quick estimation of the risk tolerance of a firm. Suppose a firm is presented with a 50/50 chance to gain x or to lose x/2 immediately. The opportunity has a positive expected value of x/4; it is therefore attractive for small values of x when the risk is acceptable. It is easy to see, using the mean/variance criterion above, that it will become unattractive when x becomes large; there is indifference between accepting and rejecting the opportunity when x is of the order of the coefficient of risk tolerance λ.

The expression for the certain equivalent of an exponential utility curve also shows that certain equivalents of independent prospects can be added (both expected values and variances of independent risks are additive). In particular, new projects can be analysed without referring to the risks inherent in the status quo situation, provided the new risks are independent from the existing risks.

[29] Mathematical expectations being a linear operator, maximum expected utility choices are invariant under any positive linear transformation of the utility scale.

[30] The curvature defined as u''/u' is equal to $-1/\lambda$ and is therefore constant. The exponential utility function is said to show constant absolute risk aversion (CARA). By comparison, a logarithmic utility function would show constant relative risk aversion (CRRA)