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DISASTER RISK MANAGEMENT BACKGROUND OF DMAPS FOR INFRASTRUCTURE

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ABSTRACT

The first part of this paper is a situationer for the Philippines in the most recent (2009) UN global assessment report that ranked it among the first 14 of approximately 200 countries and economies whose population is most at risk from earthquakes, cyclones, landslides, and floods. Second is an introduction of DMAPS for Infrastructure, a new (2009) public-private partnership agreement for disaster mitigation, adaptation, and preparedness strategies for infrastructure, involving scientists and engineers in the Philippines; this may be viewed as having evolved from the Philippine Institute of Civil Engineers DMAPS that was first conceptualized five years earlier (2004), and DQRP that was first institutionalized four years even before (2000), both volunteerism programs by Filipino civil engineers. Third and main part is a framework of concepts and terminologies that the author proposes for engineers and scientists to harmonize among themselves and with professionals in finance, medicine, and other disciplines. The author proposes that fundamental issues common to various professional disciplines concerning the management of risk be associated with four general steps of risk management, easily remembered as R-I-S-K: Recognize, Impute an estimate, Survey over time, and Keep inside tolerance range. The particular type of risk needs to be clearly recognized (in step 1 of risk management), before deciding on the ordinal or other level of measure to impute an estimate (in step 2 of risk management). The older paradigm of managing disaster meets the newer paradigm of managing risk, at the step of surveying the risk over time (in step 3 of risk management), by virtue of the recognition that risk factors do evolve. Risk reduction is cited as the preferred mode of keeping disaster risk inside the tolerance range, yet many risk control modes indeed exist (in step 4 of risk management) from many viewpoints. Highlights of the four steps of the risk management spiral are summarized; ideally, each complete cycle of risk management R-I-S-K brings down the level of uncertainty and reduces the risk. It is proposed that the DMAPS for Infrastructure public-private partnership program be viewed in this framework. In appendices, this paper includes three essays that offer an alternative way of appreciating risk management concepts and terminologies.

Key words : risk factor; hazard; exposure; vulnerability; uncertainty; human factor; risk management spiral; volunteerism

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1. SITUATION OF THE PHILIPPINES

The United Nations International Strategy for Disaster Reduction ranks the Philippines within the first 14 countries, among approximately 200 countries and economies, in terms of absolute and relative multi-hazard mortality risk for earthquakes, cyclones, landslides, and floods (UNISDR 2009a). Figure 1 shows a scatter diagram of the mortality risks in different countries. In the Philippines, on average 820 persons annually are mathematically expected to perish due to those hazards.

For economic risk, the UNISDR (2009a) does not present a single combined economic risk index. There is economic exposure, which may be indexed on gross domestic product (GDP), and there is economic vulnerability. The Philippines, according to the UNISDR grouping in the 2009 report, happens to be in the medium (middle) group of countries in terms of economic vulnerability.

The two great Philippine storms of September-October 2009, Ondoy (Ketsana) and Pepeng (Parma), highlighted the risks.

Over 920 persons died; infrastructure, agriculture and private properties worth over Php38-B were damaged; and over 8 million people were directly affected (NDCC 2009b).

Even before the twin storms, the Philippine disaster risk management community was in the process of considering the UNISDR 2009 Global Assessment Report. The Foreword states it well not only for the Philippines but for most countries: “While we cannot prevent natural phenomena such as earthquakes and cyclones, we can limit their impacts. The scale of any disaster is linked closely to past decisions taken by citizens and governments – or the absence of such decisions. Pre-emptive risk reduction is the key. Sound response mechanisms after the event, however effective, are never enough.”

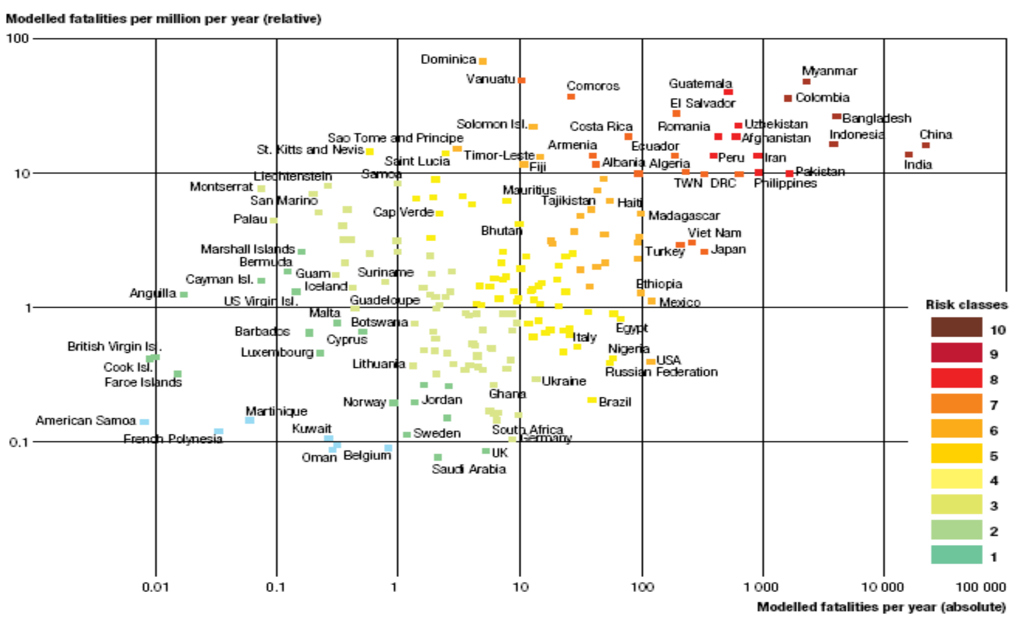


Figure 1. Absolute and relative multi-hazard mortality risk (UNISDR 2009a, Figure 2.34)

Citizens and governments indeed must respond and rehabilitate in the aftermath of the disasters (Figure 2), and must mitigate, adapt and prepare in consideration of the risks. Given the unbounded nature of disasters, scientists and engineers must contribute in research and in volunteerism.

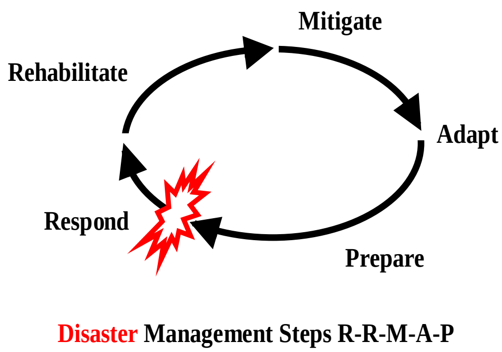


Figure 2. Steps of disaster management

2. INFRASTRUCTURE, DQRP, AND DMAPS

Blaikie et al. (1994) provides an excellent reminder that hazards, vulnerabilities, risks, and disasters are not purely natural or physical but equally human or social. Nonetheless, engineering-based technologies for infrastructure are naturally expected by society to provide a line of defense. Infrastructure has to provide safety and security, while infrastructure itself has to be safe and secure.

2.1 DMAPS for Infrastructure

Disaster mitigation, adaptation and preparedness strategies for infrastructure (DMAPS for Infrastructure) was formally agreed upon in July 2009 as a common goal by the National Disaster Coordinating Council (NDCC), Department of Public Works and Highways (DPWH), Department of Environment and Natural Resources (DENR), Department of Science and Technology (DOST), Philippine Institute of Civil Engineers Inc. (PICE), University of the Philippines Diliman (UPD), and Office of Civil Defense (OCD).

The seven parties in the agreement, comprising national government agencies, private sector, and academe, agree to develop and apply science-based maps and models of natural hazards in the environment such as earthquake, storm, landslide, flood and others; science-based maps and models of vulnerable infrastructure and environment; and engineering-based technologies to reduce the associated natural disaster risks.

Science-based maps and models, together with engineering-based technologies, are deemed necessary in the planning, design, construction, maintenance, and management of infrastructure as practiced or enforced by government agencies and by individual member-engineers and member-scientists. At the same time, non-structural or software-side or soft-side approaches are necessary.

The parties constitute an "NDCC Task Force DMAPS for Infrastructure" to facilitate the continuing harmonization, sharing, use and update of natural hazard maps and models. The Task Force, chaired by DPWH, assists the NDCC in the implementation of various natural-disaster mitigation, adaptation and preparedness strategies for infrastructure. By the agreement, the Task Force establishes its Technical Working Group, chaired by UPD-ICE.

It is evident in the agreement for DMAPS for Infrastructure that natural hazard, population exposure, and infrastructure or structure vulnerability are regarded as risk factors that may well be the focus of the science sector, government sector, and engineering sector, respectively. Hazard, exposure and vulnerability are considered in this paper as the three generic risk factors in disaster risk. Figure 3 illustrates that risk (the volume of the prism OHEV) may be reduced by reducing at least one of the three risk factors H, E, and V. The latter part of this paper discusses risk factors further.

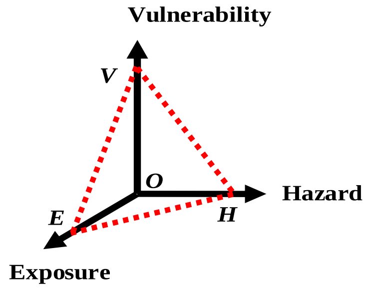
2.2 PICE DMAPS Volunteer Evaluators

The Philippine Institute of Civil Engineers had conceptualized the Disaster Mitigation and Preparedness Strategies (DMAPS) program in 2004, to encourage member engineers to compile and use various layers of disaster maps covering the area corresponding to each Chapter of the PICE: maps of past disasters; maps of current hazards; maps of vulnerable infrastructures, structures, systems, and populations; and composite maps of disaster risks.

The acronym DMAPS has since acquired double meanings, the second meaning being the use of various layers of geographic-information based maps. In effect, the map layers could correspond to the risk factors H, E and V.

Each PICE Chapter may focus on one or two natural hazards that historically affect their local area the most.

Members of the PICE Chapter are expected to volunteer to their local government units at the planning stage of infrastructures and structures. In contrast, the earlier program DQRP (disaster quick response program), by PICE together with the Association of Structural Engineers of the Philippines and the Office of Civil Defense, has been training, enlisting and deploying volunteer evaluators since 2000 who are mostly intended for rapid post-earthquake assessment of building damage.



Risk = U * H * E * V
or
Risk ≈ H * E * V

Figure 3. Risk and risk factors

With the recent setting up of the NDCC Task Force DMAPS for Infrastructure as stated above, the PICE volunteer evaluators are expected to be trained in using various science-based maps and models of natural hazards. Aside from earthquake, among the hazards being considered are: flood, landslide, tsunami, typhoon, and also fire.

PICE DMAPS volunteer evaluators, therefore, are expected to assist local government units in rapid assessment of disaster risks, while PICE-ASEP-OCD DQRP volunteer evaluators assist in rapid assessment of earthquake damage.

In the context of Figure 2, there has been an extension from DQRP as a program for managing actual disasters in steps R-R, into DMAPS as a program for managing potential disasters (i.e. risks) in steps M-A-P.

2.3 TC-DMAPS for Asia

A technical committee on disaster mitigation and preparedness strategies (TC-DMAPS) was also formed in 2007 for the Asian Civil Engineering Coordinating Council (ACECC).

ACECC comprises PICE and its counterpart civil engineering societies including the Japan Society of Civil Engineers (JSCE), American Society of Civil Engineers (ASCE) and several others in the Asia and Pacific region. TC-DMAPS aims to encourage the member societies to publish and publicize various types and layers of disaster risk maps covering their respective countries or regions of operation. Risk management frameworks are also to be compiled, serving as examples of best practices. The committee expects to present its contributions during the 5th Civil Engineering Conference in the Asian Region at Sydney, Australia in August 2010.

In sum, DMAPS, TC-DMAPS and DMAPS for Infrastructure all use the philosophy of dividing natural disaster risk into the risk factors H, E and V (Figure3); each factor typically assignable to a different sector or profession, the better to divide the task of disaster risk management.

Natural hazards may well be addressed by scientists. Exposure may well be entrusted to the care of local governments, together with socio-economic vulnerability.

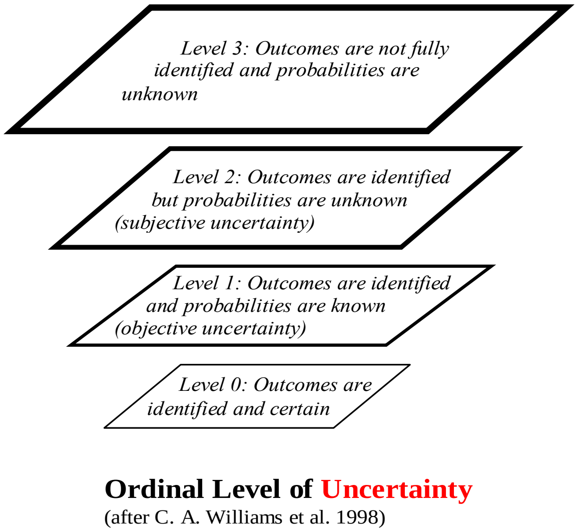


Figure 4. Uncertainty levels

Physical vulnerability may well be the focus of engineers, together with technological vulnerability. Yet everyone needs a clear understanding of the role of each other.

The remainder of this paper is a framework of risk management concepts and terminologies that scientists and engineers need to harmonize with other professionals. In fact, scientists and engineers among themselves have to harmonize their tools, too, given the multiple hazards that have initially spawned distinct methodologies. If multi-hazard disaster risk has to be managed, a common risk management framework has to be devised. Four general steps of disaster risk management are proposed in the last part of this paper.

3. UNCERTAINTY, OBJECT OF RISK, AND OUTCOME OF INTEREST

3.1 Uncertainty

Risk arises from uncertainty in an outcome of interest. Hence it is appropriate to lay the framework of concepts and terminologies on the philosophy about uncertainty itself. Williams et al. (1998) proposed to classify uncertainty into the following qualitative levels:

"At Level 0, outcomes can be predicted with precision, as in [deterministic] physical laws and natural sciences.

"At Level 1 [objective uncertainty], outcomes are identified and probabilities are known, as in games of chance like cards or dice. At Level 2 [subjective uncertainty], outcomes are identified but probabilities are unknown, as in fire, automobile accident, and many examples of investment. At Level 3, outcomes are not fully identified and probabilities are unknown, as in space exploration and genetic research."

While Williams et al (1998) may seem to describe most science to be at Level 0 uncertainty, Ang and Tang (2007) describe aleatory uncertainty and epistemic uncertainty in engineering. Engineers would consider randomness or variability in nature to be the origin of aleatory uncertainty. For instance, measure and remeasure as they may the velocity of shear waves through the ground, the value that they get each time may vary. Meanwhile, imperfections in the engineers' formulas and models create the epistemic uncertainty in the resulting predictions (Ang and Tang 2007).

In fact science has long enefited from a probabilistic (nondeterministic) paradigm, in the tradition traced by Bernstein (1996) for western science. His book 'Against the Gods: the Remarkable Story of Risk' (Bernstein 1996) is often recommended as a readable presentation of the history of probabilistic thought in engineering and the applied hard sciences (Taleb 2004).

Williams et al assert that the level of uncertainty arising from a given type of risk can depend on the entity facing the risk; for example, an insurer or a government entity may regard the risk of earthquake as being at Level 2, while the individual may regard the earthquake as being at Level 3. This difference in perspective may be a consequence of an ability or inability to estimate the likelihood of outcomes.

The significance of the entity and its ability or inability to estimate the likelihood of outcomes is central to the concept of "risk intelligence" as later proposed by Apgar (2006). Apgar (2006, p.14) distinguishes thus: "Random risks… are indeterminate: no knowledge will reduce their uncertainty…" "With nonrandom risks, every risk taker is in a different position to learn about what drives them. So for every nonrandom risk, some risk takers can reduce their uncertainty more than others…"

Uncertainty, like beauty, may be in the eye of the beholder.

3.2 Objects of Risk

Just as uncertainty may depend on the entity's view, the target or subject of uncertainty – hence the object of risk – depends on the value system of the person, party or entity.

While there are countless things that a person, party or entity may value, which may be subject to uncertainty, the author has proposed (Pacheco 2007) that the choice of risk management approach can be guided by associating with only three generic objects of risk, namely: Life, Way of life, and Property. These risk objects are illustrated together in Figure 5.

Various elements at risk may be considered to correspond to the same risk object. From various parts of the UNISDR Terminology on Disaster Risk Reduction (UNISDR 2009b), examples of elements at risk may be matched with the generic risk objects of life, way of life and property, as illustrated in Table 1a. As will be discussed below in the last part of this paper, the steps of risk management will depend on which risk object predominates.

3.3 Outcomes of Interest

Any ambiguity of the risk object may be reduced when the outcome of interest is defined. Outcomes of interest, being more detailed, may substitute for elements at risk (as in examples below and in Table 1b).

Either ultimate outcomes or surrogate endpoints may be used. An ultimate outcome may be the chronologically final outcome of interest, or the outcome of greatest interest.

As an example, consider the risk of earthquake damage to a house. Should the owners consider that property is the risk object, specifically that the house cost is the element at risk, they would be interested in the initial cost of acquiring the house plus the present value of the expected cost of repairing it in cases of earthquake within the time window of interest, say 50 years of ownership.

As another example, the owners of a hotel may consider that way of life is the risk object, specifically that the conduct of business is the element at risk. Then they may be interested in the annual net income from operations after deducting the costs in cases of earthquake.

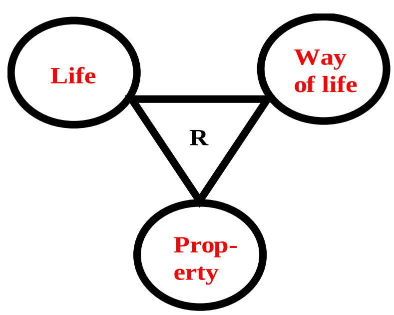
When it concerns life as the risk object, the ultimate outcome of concern is death, i.e. mortality. Note that the UNISDR (2009a) Mortality Risk reported in Figure 1 is in this category.

Table 1a. Risk objects and examples of elements at risk culled from UNISDR (2009b)

Risk object (generic)	Elements at risk (examples)
Life	People
Way of Life	Health status, public safety, livelihood, service, social & economic order, environment
Property	Asset, physical structure, technical facility & system, land

Table 1b. Risk objects and detailed examples of elements at risk (note some interrelated examples)

Risk object (generic)	Elements at risk (may include outcome of interest)
Life	City children in infected flood water; rate of mortality
Way of Life	Village adults in farm in drought; number of tourists; quality of water at the beach; perception by people outside the country; annual net income of hotel
Property	Stability of house on slope; resale value of house; maintenance or rehabilitation cost of hotel



Three Objects of Risk

Fig. 5. Risk objects

Proxy or surrogate endpoints are of interest sometimes, rather than ultimate outcomes, especially if such surrogate endpoints may be surveyed quite reliably and more promptly, in anticipation of the ultimate outcomes. For instance, development of cardiovascular disease (CVD), i.e. morbidity, may be used by some as a proxy for death due to CVD, i.e. mortality. In this sense, medical workers use morbidity as surrogate endpoint in place of mortality, the ultimate outcome.

It may still be argued, however, that the more relevant surrogate endpoint in practice is "the quality of life." Note that quality of life corresponds to way of life as the generic risk object.

In the above context, depending on the nature of the specific medical condition, morbidity may be an ultimate outcome for way of life (when medical condition is chronic) or a surrogate endpoint for life itself (when medical condition is terminal).

It may asked in the context above, would disabling injuries in an earthquake be more important than deaths? What ultimate outcomes or surrogate endpoints would be important? Would the relative importance differ in communities with varying affluence? Would a democratic country and an autocratic country have different approaches?

In summary, just as uncertainty depends on the entity's view, and the target or subject of uncertainty – the object of risk – depends on the value system of the person, party or entity, so does the outcome of interest depend on the values of the entity, party or person.

Uncertainty in the outcome of interest becomes risk.

4. RISK DEFINITIONS

4.1 Neutral Description or Definition

Risk is "a condition in which there is a possibility of a deviation from a usual outcome that is expected or hoped for." (Vaughan 1997) This is a most neutral description of risk. Other definitions abound, layman definitions included.

A Merriam-Webster definition is typically more partial to the mention of loss; risk is defined therein as "a possibility of loss or injury." (Risk 2009) The United Nations International Strategy for Disaster Reduction recently updated its terminology on disaster risk reduction (UNISDR 2009b), stating that: "risk is the combination of the probability of an event and its negative consequences."

Below is a distinction between pure risk and speculative risk, and between absolute risk and relative risk (see also Table 2). Distinguishing these concepts is one key to harmonizing our approaches to risk management in different disciplines and sectors.

4.2 Pure Risk

Pure risk is a label (mostly originating from the study of insurance) for "those situations that involve only the chance of loss or (at best) no loss" (Vaughan 1997). "Pure risks are associated with hazards such as health, safety, environment, and security where success with risk control can never be better than removal of the hazard so that exposure is zero and no harm can result, e.g. no accidents, zero product defects, no crimes." (Waring and Glendon 1998)

Regarding the risk as pure, a disaster risk reduction approach would aim at reducing the expected average loss to nearly zero.

Following a traditional thinking among insurers, the risk due to earthquake is pure risk and as pure risk it is insurable. Yet some kind of speculation ("impure") may at times come into the picture, as described below.

4.3 Speculative Risk

Speculative risk describes a situation that "holds a possibility of either loss or gain" (Vaughan 1997).

In business, for example, risk-taking means taking a chance to either lose or gain, hoping for the latter. When regarding the risk as speculative, a risk control approach would aim at minimizing the maximum probable loss while targeting a desired gain (all within a certain level of confidence).

From the point of view of the earthquake insurance mentioned above, it may be asked, should moral hazard and morale hazard come into the picture (as discussed further below), could earthquake risk become speculative?

Not a few aggressive business people are known to have dealt earthquake risk a speculative hand: they have betted, in relatively short time intervals, on low-cost structures or systems exposed to seismic hazard, hoping to gain a lot financially in the near term yet willing to lose some in the long term.

4.4 Absolute Risk

Absolute mortality risk has been estimated by UNISDR (2009a) in terms of the number of fatalities per year, associated with earthquakes, cyclones, floods, and landslides (Figure 1).

Another concept of absolute risk (attributable risk) is convenient when it is perceived that two or more risk factors are potentially contributing to the risk and yet not all of these risk factors have been pre-identified. In medical epidemiology, if one risk factor is pre-identified, and if it is possible to estimate the risk in a population that is exposed to that risk factor and the risk in another population that is similar yet not exposed to that particular factor, then absolute risk (or attributable risk) due to that particular risk factor may be taken as the difference of the said two risks. (See, for instance, Bonis 2006).

Absolute risk is "useful as a measure of public health cost or benefit of some exposure, because it subtracts from the exposed group the cases that would be assumed to have occurred anyway." (Boslaugh and Watters 2008)

4.5 Relative Risk

Relative mortality risk has been estimated also by UNISDR (2009a) in terms of the number of fatalities per year per million population in the exposed zones (Figure 1).

Another concept of relative risk (risk ratio) is defined in medicine (in contrast with absolute risk above) as: the ratio of the risk in an exposed population divided by the risk in an unexposed population (Bonis 2006). A relative risk greater than 1 indicates that the exposure increases the risk of the disease. If there is no relation between exposure and risk, the relative risk is 1, while if the exposure is protective (associated with lower risk of disease) the risk ratio is less than 1. (Boslaugh and Watters 2008)

Table 2. Definitions or descriptions of risk

Pure catastrophic risk	Expected outcome: an average loss; Risk: a potential catastrophic loss; Example risk object: property
Pure normal risk	Expected outcome: zero loss; Risk: a non-zero average loss; Example risk object: life
Speculative risk	Expected outcome: status quo; Risk: either a loss or a gain; Example risk object: way of life
Absolute risk	Difference of the incidence in an exposed population less the incidence in an unexposed population (Medicine)
Relative risk	Ratio of the incidence in an exposed population divided by the incidence in an unexposed population (Medicine)

4.6 Disaster Risk

A reflection of common usage in the recent 10 years or so, UNISDR (2009b) take disaster risk to mean "the potential losses, in lives, health status, livelihoods, assets, and services, which could occur to a particular community or a society over some specified future time period."

The terminology "disaster risk" itself has evolved to connect the older concept of "natural disaster" and the general concept of "risk."

After considering various nuances of the term "risk" above, the next section below discusses the usage of risk factors.

5. RISK FACTORS

5.1 Dividing Risk into Risk Factors

It is semantically convenient to divide risk into factors – risk factors. Mathematically, too, it is convenient to consider every influence to be multiplicative (rather than additive) with the other influences, especially if an attempt is made to estimate the risk in a probabilistic sense. While all the risk factors may be there but one risk factor's probability is estimated to be almost zero, then the overall risk may be deemed nil.

This approach is statistically viable; the probability of each factor may be estimated separately. From a risk management point of view, the isolation of each risk factor may be justified by the measurability or the controllability of the said risk factor.

In some professions, it may be convenient to classify a risk factor as hazard, as peril, as exposure, or as vulnerability, suggesting a specialized treatment for each type of risk factor. Figure 3 illustrates risk factors H, E, V to comprise disaster risk. A variety of usages are described below.

5.2 Hazard and Peril

In many cases people agree to attribute certain risk factors to "external" characteristics, i.e. attributes that are considered external to the elements at risk. Such "external" factors are frequently labeled as hazards: people speak of natural hazard due to forces of nature, or technological hazard due to technologies imposed on the elements at risk, or human hazard or man-made hazard due to certain human elements quite different ("extraneous") from ideal human behavior.

UNISDR (2009b) defines hazard as "a dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage."

Ishii (2009) emphasizes the human factor along with the natural factor, arguing that the causes of disaster may be classified into three: (1) natural phenomena; (2) natural phenomena induced by human activity; and (3) human activity. The first class includes earthquakes and annual floods as examples. The second includes extreme floods induced by climate-change, as well as mal-operation of utilities and infrastructures. The third may well include war and terrorism.

In insurance, moral and morale hazard are examples of human hazard. Moral hazard is "the increase in the probability of loss which results from evil tendencies in the character of an insured person... in an attempt to collect more than the amount to which he or she is entitled." Morale hazard is "the insured person's [subsequent] careless attitude toward the occurrence of losses." (Vaughan 1997)

Further in insurance, a subtle distinction can be made between hazard and peril. While, for instance, strong earthquake is a hazard, a collapsing building that may arise from this hazard is a peril, in this case a peril to life.

In view of the above examples, this paper proposes to classify hazards as either natural, anthropological, or combination of the two.

5.3 Exposure

Exposure may be characterized as the extent of contact or connection of the elements at risk with the pre-identified hazards. Extent of contact or connection may be characterized in terms of space, time, or combination of the two. In the above example, presence of human occupants in the building constitutes an exposure. It is an attractive idea that should exposure be zero then the risk would be zero regardless of the existence of hazards and vulnerabilities.

UNISDR (2009b) defines exposure as "people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses."

In the language of an earlier part of this paper, exposure may be expressed in terms of element at risk, object of risk, or outcome of interest.

In some contexts, exposure is lumped together with vulnerability (see below). However, the 2009 Global Assessment Report on Disaster Risk Reduction by the United Nations (UNISDR 2009a) makes a strong distinction between the two factors. Foremost among its key findings is that, in some countries or economies, the exposure of people and assets to natural hazards is growing at a faster rate (the economic growth rate) than the vulnerabilities of these elements are being reduced (the capacity development rate), leading to increasing disaster risks.

5.4 Vulnerability

Vulnerability is commonly described as the extent of sensitivity or susceptibility (of the elements at risk) to hazards or perils that may be pre-existing. Many times yet not always, this characterization of the influence of a pre-existing hazard or peril is deemed to include (to "factor in") the exposure.

UNISDR (2009b) defines vulnerability as "the characteristics and circumstances of a community, system or asset that makes it susceptible to the damaging effects of a hazard." It may be regarded as the inverse of resilience, which, in turn, is "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions."

Just as Figure 3 illustrates, risk factors H (hazard), E (exposure), and V (vulnerability) comprise R (disaster risk). Each of the risk factors H, E, and V in common usage can become zero at best (and cannot reverse in sign); disaster risk R is commonly a pure risk. And yet disaster risk may take on a speculative character when human hazard, human exposure, or human vulnerability comes into play.

It is to be recalled that uncertainty in each risk factor can depend on human perception. Biases can come into the picture. Following is a short discussion of biases.

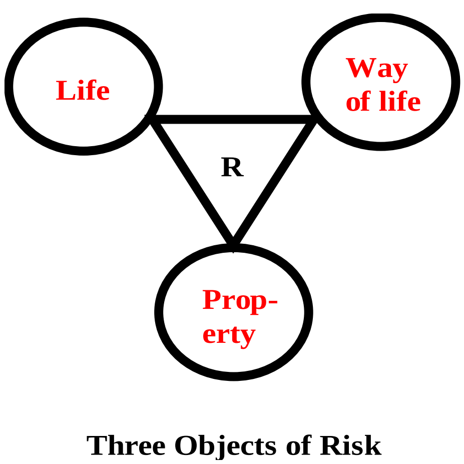


Figure 5. Risk Objects

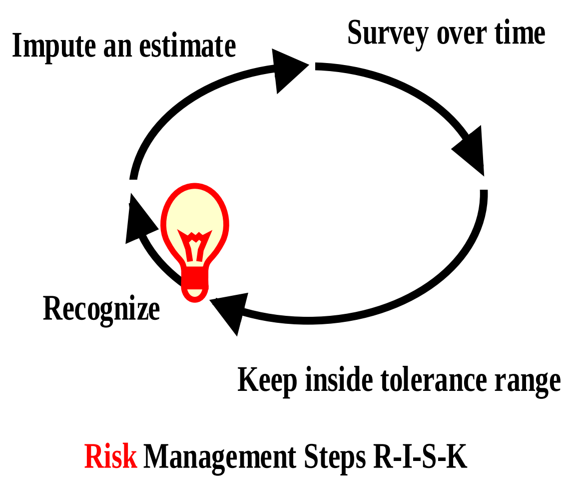


Figure 6. Steps of risk management

1. BIASES

6.1 Statistical Biases

Statistical bias usually means "systematic errors in collecting or interpreting data." Certain rules of statistical analysis are meant to minimize such bias, or at least to quantify it if it cannot be eliminated. Imputing an estimate to the risk, and surveying the risk over time, should be rid of the effect of statistical biases that are bigger or in the same order of magnitude as the range of tolerable risk.

6.2 Psychological Biases

Psychological bias or cognitive bias usually means "the frames, assumptions and beliefs that underpin [people's] thoughts, analyses and decisions." Cognitive biases in financial risk management are catalogued by Celati (2004).

Cognitive biases may exist at the individual level, at the group level, or at the society level. Some of these biases in fact correspond to well-identified statistical biases; others are yet beyond the mathematical framework of classical statistics. (Celati 2004).

Communication of risk is such a crucial activity at each step of risk management, with a corresponding feedback mechanism. Communication-feedback may be the only antidote to the usual doses of bias.

7. PARADIGM SHIFT

7.1 Managing Disasters

It used to be the framework of the National Disaster Coordinating Council of the Philippines that the four stages of disaster management are: mitigation (e.g. proper seismic design and construction of structures); preparedness (e.g. proper assessment of structural condition as it is); response (e.g. proper closure or reopening of a structure after an earthquake); and recovery (e.g. proper redesign, reconstruction or rehabilitation after an earthquake). That is, there are two pre-disaster stages and two post-disaster.

By UNISDR (2009b) definitions: mitigation is "the lessening or limitation of the adverse impacts of hazards and related disasters."

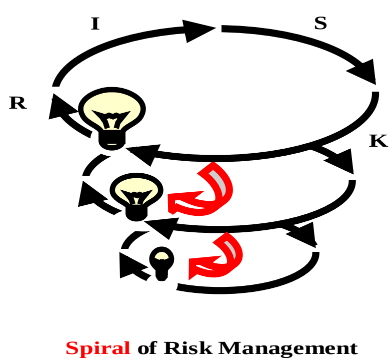


Figure 7. Spiral of risk management (with three cycles shown)

With the more recently heightened awareness of climate change hazards, a subtle distinction has emerged between mitigation and adaptation. (See Figure 2.) Adaptation is "the adjustment in natural or human systems in response to actual or expected climactic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

Preparedness is "the knowledge and capacities ...to effectively anticipate ... the impacts of likely, imminent or current hazard events or conditions."

Response is "the provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected."

Recovery is "the restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors."

7.2 Managing Risks

Now the NDCC is actively promoting disaster risk reduction and other forms of disaster risk management, by directly focusing on the risk factors of hazard, exposure, and vulnerability. Human factor is considered in many types, too.

Globally the paradigm is shifting, as above, away from managing actual disasters and toward managing potential risks. The paradigm is shifting away from dealing with the product (i.e. disaster or risk) and toward dealing with the underlying factors (i.e. risk factors).

UNISDR (2009a) goes as far as recommending dealing more directly with so-called underlying "risk drivers" such as poor urban governance, vulnerable rural livelihoods, and declining ecosystems. It is very apparent that disaster risk is not fully natural.

"Disaster risk management is the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disasters." (UNISDR 2009b)

8. SPIRAL OF DISASTER RISK MANAGEMENT

Two advantages can derive from harmonized – not necessarily uniform – treatments of risk issues by various professions. One, the various professions themselves may benefit from learning and sharing those risk management tools that are truly commonly applicable. Two, the various professions may better serve the layman and general public by clarifying those issues that still have varying treatments in their respective professional applications.

Four general steps of risk management are proposed (Figure 6), easily remembered as R-I-S-K: Recognize, Impute an estimate, Survey over time, and Keep inside tolerance range. The particular type of risk needs to be clearly recognized (in step 1 of risk management), before deciding on the ordinal or other level of measure to impute an estimate (in step 2 of risk management). For example, see Table 2.

The older paradigm of managing disaster meets the newer paradigm of managing risk, at the step of surveying the risk over time (in step 3 of risk management), by virtue of the recognition that risk factors do evolve. Risk reduction is cited as the preferred mode of keeping disaster risk inside the tolerance range, yet many risk control modes indeed exist (in step 4 of risk management) from many viewpoints.

Ideally, each complete cycle of risk management R-I-S-K brings down the level of uncertainty (Figure 4 and Figure 7) and reduces the risk. It is proposed that the DMAPS for Infrastructure public-private partnership program be viewed in this framework. Hence the examples cited are predominantly about infrastructure.

8.1 Recognize the Risk or Risk Factors

Each element at risk should be identified, as well as the generic risk object to which it corresponds most closely. The outcome of interest should be identified as far as each element at risk is concerned. To be manageable, this outcome of interest should be describable and measurable, at least at the ordinal level of measurement.

People, property, systems or other elements may be exposed to the hazards. Life, way of life, and property may be the generic risk objects. Either pure or speculative or a combination of both, the outcome or outcomes of interest have to be identified; potential deviation from every such outcome has to be regarded as risk (Table 2).

When risk factors are identified, these may be the direct target of the management activities. Risk factors that correspond to the same risk object may be conveniently aggregated in the next step of the risk management process. An example is the mortality risk due to earthquakes, cyclones, landslides or floods as aggregated by the UNISDR (2009a). However, the remaining challenge would be the attempted aggregation of risks that apply to different risk objects.

8.2 Impute an Estimate

Risk being a condition in which there is a possibility of a deviation from a usual expected outcome or desired outcome, to estimate risk should be to estimate this possible deviation. For this step, the appropriate level of measurement should be decided.

Three formulations may be considered. For a pure catastrophic risk, an expected average loss may be the expected outcome during the period, and the corresponding risk may be a potential catastrophic loss that is much bigger, perhaps to be estimated by extreme value theory (Table 2).

Earthquake disaster risk is most traditionally associated with the first formulation above. Yet disaster risk reduction approach now aims at reducing the expected average loss itself to nearly zero.

As an alternative formulation, zero loss may be the expected outcome, and the identified risk may be any non-zero average loss over the period. This may be “residual risk” as defined by UNISDR (2009b): “the risk that remains [in unmanaged form] even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.” This second formulation considers a pure normal risk.

Still, a third formulation is possible. For a speculative risk, the status quo (no change) may be the expected outcome, and the identified risk may be either a loss or a gain, perhaps to be estimated by normal probability theory.

In natural disaster risk management, say for earthquake risk or flood risk, it is convenient to estimate the following risk factors separately first and then to overlay them to obtain the risk product: natural hazard; population exposure; and population vulnerability. It is also possible to use statistical data of past losses and estimate the present relative risk directly, without dealing explicitly with the constancy or the variability of any of the risk factors.

It is noteworthy that the purpose of the UNISDR (2009a) global risk analysis is to decipher global patterns and trends in risk and it does not and cannot substitute for detailed national and local-level risk estimates.

8.3 Survey the Risk or Risk Factors over Time

Periodic, repeat estimations of the risk level should be carried out, conscious of the fact that the risk factors typically evolve over time. In the true sense of management, this step includes some projections or predictions concerning the risk factors, instead of plain history-taking. Consistent tools or measures should be used at every interval during the surveying period; otherwise this step should make the proper connection between the old and the new tools or measures.

The old paradigm of disaster management and the new paradigm of risk management overlap at this risk-survey or risk-surveillance step. Distinction is made between rapid-onset disasters and slow-onset disasters. Distinction is made also between pre-disaster stages and post-disaster stages of management.

8.4 Keep Risk Inside Tolerance Range

Within acceptable limits the risk level should be contained. Various actions may be considered at this step, singly or jointly: risk avoidance (for pure risk) or risk prevention (for speculative risk); risk reduction (for pure risk); risk deferment; or risk enhancement (for speculative risk); risk retention; risk transfer; risk sharing; risk diversification; etc.

In the case of the UNISDR (2009a), clearly the emphasis is on risk reduction: "the over-riding message of the Report is that reducing disaster risk can also help in reducing poverty, safeguarding development and adapting to climate change..."

Keeping risk under control takes a variety of forms: structural or hardware measures; and non-structural or software measures. Risk control may target a variety of factors: natural factors (nature-induced); and anthropological factors (man-induced). Risk control concerns many professions indeed. And everyone should be aware of risk control actions that spawn other risks, which in turn need to be recognized and managed.

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APPENDIX “A”– RISK: SPECULATIVE OR PURE?
OR, WHAT WOULD RSP SAY ABOUT RISK?

If he were alive today, our dearly beloved Dr. Raymundo S. Punongbayan – or RSP as he was known during his long and distinguished service as director of PHIVOLCS (Philippine Institute of Volcanology and Seismology) – he would probably not mind my choice of topic for an essay on an occasion to honor him. I chose the topic of *risk* because I believe that RSP handled this subject very well. As well, I believe that he would want us to become more comfortable with it, too.

RSP invariably chose to do something about risk, rather than ignore it. His consistent, constant advice was for us to rationally consider the risk due to earthquake, or tsunami, or volcanic eruption, or storm. His appreciation of risks resulting from *natural hazard* was so sharp and keen, as his grasp of risks – meaning, the combined *exposure* and *vulnerability* to some *uncertainty* in the outcome – of programs in research, education, or advocacy, due to *societal hazard* or *human hazard*.

The great thinker and doer that he was, RSP was never one to shirk away from risk. He risked his reputation, for example, when he advocated, with all his power and against all criticism, the establishment of a pioneering master's degree program in earthquake engineering at PUP (Polytechnic University of the Philippines). By then, the number of potential enrollees was very uncertain, and the failure of his idea seemed foreordained. RSP even risked – and lost – his own life in trying to reduce the risk due to landsliding in the mountainous provinces of the Philippines nestled in the path of rain and wind storms from the Pacific.

Risk is a topic that is both simple and complex at the same time.

Tentatively, we may agree that *risk* as a noun simply means “a condition in which there is a possibility of a deviation from a usual *outcome* that is expected or hoped for.” *(Vaughan 1997)* The concept applies even to death or taxes – the only things in life that are said to be certain – when we speak, for example, of risk of untimely death or risk of incorrect tax provisions. In this sense we find risk everywhere; the risk that we recognize depends on our definition and estimation of the outcome or outcomes that matter to us. Thus, life span and tax amount are outcomes that are subject to risk, even if death itself and tax itself are granted to be certain.

Simple? Complex, too. Complexity becomes evident when we attempt to qualify (to define) or to quantify (to estimate) different examples of risk. “Typically, risk is treated (in both research and practice) as a vaguely connected set of quite disparate topics,” *(Waring and Glendon 1998)* Vaguely connected but distinct subjects of risk there are many indeed. The menu ranges from earthquake and storm to terrorism, environmental accident, and fire, even bioterrorism and disease epidemic, yet also technological, industrial, social, political, and financial disruptions.

It would be simpler if harmony – not necessarily uniformity – may be achieved by us researchers and practitioners in the perspectives and procedures that we use in treating and managing risk in our respective professional disciplines. First, the various professions themselves may benefit from learning and sharing those risk management tools that are truly commonly applicable. Second, the various professions may better serve the layman and general public by clarifying those issues that still have varying treatments in the respective professional applications. “There is a need to introduce a broader perspective to the subject of risk and to recognize that approaches towards risk and towards management ... are beginning to converge." *(Waring and Glendon 1998)*

As yet, we all use the term risk at one point or other but frequently assign to the word various intended meanings, or context, or subtext. Thus far in this essay, I may have used the word risk with at least two or three different senses of meaning. Either the risk recognition varies, or the risk estimation varies, or both aspects vary among earthquake engineers, insurers, medical doctors, community organizers, industrial officers, political leaders, and financial managers, among others. Which risk do we see? Is it the expected *catastrophic loss*, perhaps estimated by extreme value theory, as in major earthquakes or in stock market crashes? Or is it the expected *average loss*, perhaps estimated by normal probability theory, as in the development of a common disease or in the payment of annual taxes? Or is it the deviation (*loss or gain*) from expected value, perhaps estimated by normal probability theory, as in an investment on academic research or in an election?

At the moment, we may take a listen into the heart of the disagreement regarding the identification of risk or the estimation of risk. For one thing, our heart I believe is frequently confused by the distinction – or lack of distinction – between *pure risk* and *speculative risk*.

"Pure risks are associated with hazards such as health, safety, environment, and security where success with risk control can never be better than removal of the hazard so that exposure is zero and no harm can result, e.g. no accidents, zero product defects, no crimes." *(Waring and Glendon 1998)* In short, pure risks refer to "those situations that involve only the chance of loss or (at best) no loss." *(Vaughan 1997)* Earthquake engineers and medical doctors, among others, would then seem to be dealing with pure risks. Really? We will return to this point towards the end of this essay.

In contrast, speculative risks describe situations that "hold a possibility of either loss or gain," *(Vaughan 1997)* as in academic programs or in financial investments. However, not many academicians and not all finance people would admit to being speculators. What gives?

Can we now at least try to answer the sample question: "Is the risk due to earthquake speculative or pure?"

If we follow the traditional thinking among insurers, then the risk due to earthquake is pure risk – as it involves only the chance of loss or at best no loss – and as pure risk it is insurable. It is insurable in principle, indeed, but it is seldom insured in our country in fact. And why not?

Exploring the field of insurance nowadays, indeed we see a widening perspective of risk management. *(See e.g. Harrington and Niehaus 1999; Williams et al, 1998.)*

In fact, hesitant insurers in the country are not too wary about the natural hazard of an earthquake alone. The insurers among us need only to make the earth scientists and earthquake engineers work even harder on recognizing or estimating this natural hazard. Or, make the engineers work on reducing the vulnerability of structures and facilities. *(See e.g. Coburn and Spence 2002; Pacheco 2004)* What seem to still trigger wariness more are the human *moral hazard* and *morale hazard*, which as we shall see are manifestations, in turn, of human *vulnerability* to impure thoughts.

Moral hazard is "the increase in the probability of loss which results from evil tendencies in the character of an insured person... in an attempt to collect more than the amount to which he or she is entitled." Morale hazard is "the insured person's [subsequent] careless attitude toward the occurrence of losses." *(Vaughan 1997)*

Here is an example of supposed pure risk being affected by that human desire not only to avoid a loss, but also to wish a gain while possibly ignoring the *odds*.

RSP, the diligent, methodical mind that he was, would argue that, inherently, earthquake risk is speculative risk, too. He was acutely aware of the fact that there would always be people taking the risk of earthquake devastation in Metro Manila *(see e.g. Solidum et al 2004; WB 2004)*, or in other centers of livelihood that happen to lie in the many earthquake zones of the world *(see e.g. Blaikie et al. 1994)*. There would always be people thinking not only of a sure loss in some unknown future, but also of a possible economic gain in the near present. In our management of the risks for as long as societal or human behavior in this way is considered together with the behavior of nature, we may be well advised by RSP to view earthquake risk management as a management of both speculative risks and pure risks.

In other words as RSP was wont to say, with risk as with many things in life, we do not need a narrow professional or disciplinary view. Instead, by his counsel, we need a broad human perspective. *(See e.g. Kameda 2004; ADRC 2005.)*

Let us summarize.

I chose the topic of risk for this essay to honor the late Dr. Raymundo S. Punongbayan or RSP, because I thought that RSP handled this subject very well, and that he would want us to become just as comfortable with it.

The topic of risk itself is both simple and complex. The preferred definition of risk, or the preferred estimation of risk, is still far from universal among many disciplines and professions. While we find risk everywhere, the risk that we recognize depends on our definition and on the estimation of the outcome or outcomes that matter to us.

Meanwhile, our heart I believe is frequently confused by the distinction – or lack of distinction – between pure risk and speculative risk. For instance we may ask, “Is the risk due to earthquake speculative or pure?” If we follow the insurers’ traditional focus on the natural hazard, and concede that there is only something to lose and nothing to gain, then the risk due to earthquake is pure risk. I think that RSP would observe – and argue – further that earthquake risk is speculative risk, too, as it also involves human hazard (or human vulnerability?), the human desire not only to avoid a loss in the long run but also to wish – and work for – a gain in the short run while possibly ignoring the odds.

RSP (Raymundo S. Punongbayan) would say about earthquake risk, “Risk is both Speculative and Pure.” ●

APPENDIX “B”– MANAGEMENT = MANAGE MEN
OR, DO MEN REGARD RISK RATIONALLY?

Men – and women – like to manage things. We like to think that we manage our life, our time, and every risk that we face in our lifetime. But do we really manage to do all that? Do we even know how to regard risk rationally? If we don’t, we may well need only to manage ourselves to prevent us from self-inflicting any losses, or from sacrificing better gains.

In this essay, let us review three books on people's insights on risk, by practitioners of reputable standing in the financial risk management world. *(Celati 2004; Taleb 2004; Bernstein 1996)* Believe it or not, from finance (or engineering or medicine) such a review goes back to the basics of human behavior.

"The dark side of risk management: how people frame decisions in financial market" *(Celati 2004)* – with tools from behavioral science and cognitive psychology – is an attempt to unlock the key question of: Are we, and our organization, aware of the frames, assumptions and beliefs that underpin our thoughts, analyses and decisions?

Cognitive frames of risk at three levels of application are postulated in this first book: the systemic frame of risk, the organizational frame of risk, and the individual frame of risk. This book's frame-of-risk theory considers that the key element to explain people's behavior and people's decision in the whole variety of settings involving uncertainty is... *bias*.

While bias in *statistics* may usually mean "systematic errors in collecting or interpreting data," *(e.g. Hennekens and Buring 1987)* let us here extend our view to a variety of biases in *behavioral science* and *cognitive psychology*. Let us talk about biases that may affect not only the definition of risk ("interpreting data") or the estimation of risk ("collecting data"), but also the periodic monitoring of risk level or the attempts at control of risk within acceptable limits.

We have a chance now in this essay to glance upon a number of biases exposed from "the dark side." *(Celati 2004)*

Overconfidence – at the preface of this book's list – is excessive faith in the information that we use in our decisions.

Prospect theory (attributed to Daniel Kahneman and Amos Tversky in the 1970s), the "mother of most biases," asserts that people's preferences do shift when dealing with decisions concerning risk: we become *risk-loving* above our so-called reference point, and *risk-averse* below that point.

Among the biases that individuals may have, perhaps *representativeness* or *similarity bias* is the simplest. Our mind uses a small sample to draw inferences and conclusions that will be used (wrongly) for a broad population.

Anchoring or *adjustment bias* refers to people's tendency to remain fixated on certain pieces of information regardless of their relevance (or irrelevance).

Mental accounting, *loss-aversion* and *endowment bias* are interrelated. We tend to account mentally – in effect separately and inconsistently – for losses and gains. Contrary to assumptions of conventional economics theory, human aversion to incur a loss does increase (not decrease) as one's wealth grows. In the meantime, we may value wealth differently depending on the timing and ways in which it was acquired.

Availability bias (Celati 2004), perhaps the most prominent of cognitive frames, works through information retrieval, construction or simulation. We tend to retrieve events that are more vivid, more visual, seemingly more likely, or simply more recent. Otherwise we tend to construct or simulate scenarios with unrealistic mix of fantasy and reality, or ignoring conditional probability that depends on prior events, or using conditions that are excessively and unrealistically favorable.

Survivorship bias and *sequential information bias* may be regarded as twins. When we analyze certain surviving and successful entities, we tend to think that they survived and succeeded because they were good. In fact there could well be others that were also good but did not survive or succeed (due to other factors) and in effect were wrongfully excluded from our scope of analysis. *(See e.g. our second book, Taleb 2004.)* Sequential information processing bias is people's tendency to analyze situations and problems as if they were a linear sequence of steps, regardless of correlations and interrelationships with other contributing factors. *(Celati 2004)*

Gambler's fallacy means the decision-maker's misconceptions about probabilities and how they apply after a streak of outcomes. This means confusing *relative frequency of incidence* in the recent history with *probability* in the future.

Negative feedback or *denial* – do we not know about this already? This is the all too familiar tendency to ignore feedback information that conflicts with the decision-maker's opinions or actions.

Selective attention bias refers to our tendency to focus – and to focus exclusively – on pieces of information that conform to our views and opinions. It is the flipside of negative feedback or denial.

Binary bias is the tendency to categorize problems in simplistic pure yes/no, black/white or good/bad terms.

Illusion of control is the belief that one has the means to control what is actually a random process. In other words, it is a case of being "fooled by randomness." *(Taleb 2004)*

Self-attribution bias, or simply *attribution bias*, refers to the attribution of one's success to one's skill and ability, and attribution of failures to external causes.

Hindsight bias, last in our list but certainly not the least common, is the tendency to use the past to see one's own views confirmed after the fact.

Group biases also exist, aside from some 88 individual biases like those already mentioned. *(See sources cited by Celati 2004.)* Our first book names a few big ones: *groupthink* (where group consensus results in decisions that are sub-optimal compared to individual preferences); *herd behavior* (where one overweighs other people's views in forming his own); and *game theory*. It may be argued that game theory belongs in another category. Game theory postulates that one's decision on utility will not be independent of other's preferences (contrary to an assumption by older conventional economics theory) but, rather, will take those to some account. *(Game theory was first developed by John Nash.)*

No, we will not be too embarrassed now to admit it. Men and women, individually and in groups, can hardly be the consistently rational thinking creatures that we wish to project ourselves to be. The first management call that we must heed is the management of men's and women's biases.

Would we do much better if we just religiously computed the appropriate probabilities? Would the appropriate probabilities cure us of the availability bias, and rid us of the gambler's fallacy? Indeed, as risk is so frequently addressed through mathematical probabilities, we now turn to the surrounding debate of "knowledge versus computation".

Probability is certainly tricky. Our third book, 'Against the Gods' *(Bernstein 1996)* is often recommended as a readable presentation of the history of probabilistic thought in *engineering* and the *applied hard sciences*. *(Taleb 2004)* Our second author, however, "completely disagrees with [our third book's] message on the measurability of risks in the social sciences." He says, "In economics, for instance, we have very large models of risk calculations sitting on very rickety assumptions (actually not rickety but plain wrong). They smoke us with math, but everything else is wrong. Getting the right assumption may matter more than having a sophisticated model." *(Taleb 2004)* The global financial crisis of 2007 in large measure reminded us just how fast the rickety could fall apart.

That is quite a sobering thought.

But let us end this essay on an upbeat note (a case of selective attention bias?). After all, our second author has devoted his entire book, not only the frank passages that we cited, "for fun" and designed it "to be read (principally) for, and with, pleasure." *(Taleb 2004)*

Our third book 'Against the Gods' argues, "The revolutionary idea that defines the boundary between modern times and the past is the mastery of risk: the notion that the future is more than a whim of the gods..." *(Bernstein 1996)*

It tells the "story of a group of thinkers... By showing the world how to understand risk, measure it, and weigh its consequences, they converted risk-taking into one of the prime catalysts that drive modern [Western] society...

"The transformation in attitudes toward risk management unleashed by their achievements has channeled the human passion for games and wagering into economic growth, improved quality of life, and technological progress."

We may even suspend the debate right there, and join the three authors together (hopefully not as an attack of groupthink). Men and women have come a long way in understanding a large part of the nature of risk, and a large part of the nature of human bias.

For good use, we continue our quest for models that have unbiased assumption *and* information. Meanwhile may randomness not fool us; may the gods protect us from our own overconfidence. ●

APPENDIX "C"– PERSPECTIVES & PROCEDURES
OR, DO WE ACT ON WHAT WE KNOW (ONLY)?

We shall examine in this essay some actions of professionals among us in finance, engineering, and medicine, as well as pieces of information that are our stock in trade.

First off, we shall make one observation: There is a good case to be made for what we may call actionable information. As professionals we love information that can trigger action. We seek information before we act. We may say, "That is my kind of information – actionable."

As managers we even speak of *framework* of action. We can almost visualize pieces of information that we assign to little, neat places in a framework, ready to be acted upon.

Since the 1990s, the financial risk management people among us appear to have gone much further and invented such mouthfuls as “firmwide integrated risk management framework.” We would mean to systematically consider – before acting to either *seek* or *avoid* more risk – information on three major types of hazards to our firms. These are: uncalculated adverse movements in general *market* prices; credit default by *counterparties*; and mal-operation in our own *organizations*. *(See e.g. BSP 2006; Jorion 2001; Marshall 2001.)*

Yet financial risk management, even the comprehensive, integrated, firmwide demanding kind, may turn out to be the easy one in some sense. Like the clients that we as financial managers serve, we are happy enough to view and use all the information about all the varied risk factors in terms of our single *element at risk* – money. But then again money must be optimized by our financial risk management actions.

Woes unto us, we, the earthquake engineers of the world, are not as lucky. Even as we plan, build, and maintain facilities at a frenetic pace, we must also manage earthquake risk – confronting natural hazard (earthquake) first and human hazard (layman) second.

Earthquakes are a trifle too difficult and tricky for engineers to master. In part this is because large and destructive earthquakes are rare, fortunately or unfortunately. Huge, caustic tremors visit quite rarely; many people have vague or no memory at all of their dark fury. Because major earthquake episodes are few and far between, people tend to ignore the risk until the next disaster happens. With no exception almost, laymen are difficult for engineers to convince, hence woe unto us earthquake engineers who are only trying to do our job well.

To do our job well, we must watch three objects of risk that are sometimes beyond monetary or material value. First, *lives* should not be lost; any physical failures in the facilities should not be so sudden as to preclude the chance of people escaping or springing to safety.

Second, *properties* should not be lost; any physical failures in the facilities should not be so extensive as to preclude repair and reuse.

Third, normal business operations and *ways of life* should not be lost or disrupted; instead, more of the good kinds should be gained. (This third object of risk spawns a speculative risk component – the possibility of either a loss or a gain.)

There is no singular element at risk that monopolizes the risk management efforts of earthquake engineers. Money is one proxy, for sure, against which can be measured the risk to way of life (third in the list above) and the risk to property (second in the list).

But how about the risk to life, the primordial value on the list above?

For good or ill, the common observation is that we as earthquake engineers have mostly shied away from information *quantifying* the risk to life. Most of the time, we have to be content with *qualifying* that all engineered facilities that result from our action, first and foremost, must protect people from bodily harm.

Early on, it has been noted that as finance professionals, we may have inordinately stressed on guarding against risk to wealth, and not with as much vigor, against risk to health. This, never mind that financial losses – even financial gains – may also cause a heart attack.

Expectedly, our recourse has been to turn to the medical doctors among us to get our fill on the perspectives and procedures that focus on risk to life.

A quick check with a popular online library of medical reviews is most instructive. *('UpToDate® Online 13.3 2006)* The phrase *risk management* is conspicuously absent in the lexicon of medical doctors.

Absent is the aggressiveness of financial managers in reflecting the effects of a multitude of hazards or risk factors into the single element at risk that is money. Absent, too, is the tentativeness of earthquake engineers in claiming qualitative but not quantitative watch over such varied risk objects as life, property, and way of life.

In medicine we find instead a more cautious – even religious – approach. Instead of *risk management*, what crowd the vocabulary of medical doctors are medical terms such as *risk factors*, *risk score*, *relative risk*, and *attributable risk* or *absolute risk*. *(We searched "risk management" in 'UpToDate' as cited earlier and noted that these search results were under "risk," among 37 related items.)* Surely it looks like we as medical doctors take our recognition and estimation of the risks very cautiously.

Risk factors mean the health hazards, both biological hazard and social hazard. For instance, for coronary heart disease – the leading cause of death in adults – among the major risk factors are gender (biological); age (biological); cigarette smoking (social); total cholesterol; HDL-cholesterol; and blood pressure (the last three may be classified as biosocial). Except for gender and age, many of these risk factors for coronary heart disease we can note to be "modifiable by specific preventive measures." *(See e.g. Wilson and Culleton, 2005.)* *Risk control* is possible.

To help us in *screening* and advising *preventive measures* for large populations, we as doctors have devised risk scores for coronary heart disease. "The model most frequently used is that developed by the Framingham Heart Study." As modified by the NCEP/ATP III expert panel and incorporating the risk factors earlier mentioned, the Framingham/ATP III point score for men of 4, 12 or 16 corresponds to 1% risk (low), 10% risk (intermediate) or 25% risk (high) of development of coronary heart disease within 10 years.

We may casually observe a few things in this score system as an example. (1) The relation between assigned risk score and derived risk percentage is proportional but not linearly so. Arguably, a proportional relationship is sufficient for our objective of *risk stratification*. (2) The risk object being estimated is way of life (*morbidity*, or development of a disease) and not necessarily life itself (*mortality*, or death). As the doctors among us nowadays would say, the more useful – more actionable – pieces of information for health risk managers may be about *surrogate endpoints*, but we just have to confirm that they are positively well correlated with the *ultimate outcomes* that matter. (3) The derived risk percentages are based on *statistical* frequency of incidence among the many thousands of participants in the decades-long study, not on purely theoretical *probabilistic* model of distribution.

Ang and Tang (2007) provide a very insightful discussion of the relation between statistics and probability theory: By classical statistical approach, the parameters of the theoretical (assumed) probability distribution are themselves assumed to be constants (yet unknown) and the statistics of the sample are used as estimators of these parameters; in the process, confidence intervals are used to express the degree of errors (or uncertainties) of estimation of the parameters. In *contrast by Bayesian statistical approach, the unknown parameters of an assumed probability distribution are themselves assumed to be random variables (i.e. not constants); in this way all sources of uncertainty associated with the estimation of the parameters can be combined formally, systematically incorporating subjective judgments based on intuition, experience or indirect information together with the statistics of the observed data, allowing prior estimates to be "improved" into posterior estimates as more data and other judgments become available. As Ang and Tang put it: Within the Bayesian context, a probability statement is an expression of the degree-of-belief, whereas in the classical statistical sense, probability is (strictly speaking) a measure of relative frequency.*

While the different professionals among us may not totally agree yet on common terms, it may suffice here in the meantime to say that we as medical doctors take pains to differentiate *relative risk* and *absolute risk* – the better for us to treat patients from varied populations and backgrounds.

"The *relative risk* (or *risk ratio*) equals the incidence [rate] in exposed individuals divided by the incidence [rate] in unexposed individuals. The relative risk can be calculated from studies in which the proportion of patients exposed and patients unexposed to a risk is known. An example is a *cohort study*, in which a group of patients who have variable exposure to a risk factor of interest are followed over time for an outcome...

"The *attributable risk* (also called the *risk difference*) is a measure of absolute risk. It reflects the additional incidence of disease related to an exposure taking into account the background rate of the disease. The attributable risk is calculated by subtracting the incidence of a disease in unexposed persons from the incidence of disease in exposed persons." *(Se e.g. Bonis 2006.)*

By many indications, practices in medicine, engineering, and finance – our three examples – vary in perspective and procedure, as much as in information and action.

Nonetheless, all three professions find common ground in the twin questions of: "How much information is presently enough for the act; and how much action is due to the present information?"

These twin questions are essential guideposts for professionals who must act – or choose not to act – with uncertain or incomplete data regarding risk objects and risk factors. These twin questions are necessary references for professionals who must take the credit, or the blame, for the perceived effect of their action, or inaction, on people's properties, ways of life, and lives. ●

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