

The problem is not that prophets were lacking - they have been in good supply at almost all times and places. Quite the contrary, almost everything that has happened, and its opposite, has been prophesied. The problem has always been to pick and choose among the embarrassing riches of alternative projected futures; and in this, human societies have not demonstrated any large foresight.

- *Herbert Simon*

Survival instinct includes quest for *tell us what will happen in the future*. It is ingrained deep in the language (Box below), self-consciousness, and all creative expressions. We want to know future happenings even if we know that *in this world, nothing is certain but death and taxes*. Such robust assertions are not very useful because the time of death remains in doubt until the event has already happened. Meanwhile measures that reduce impact of such eventualities are much sought after.

Absolute certainty is rarely to be found. As we anticipate fluctuations, prediction is the art of dealing with anxieties as a mix of certainties with defined doubt to evaluate risks. Consider response to risks of low probability but of high consequence events. In the aftermath of the terrorist attack on September 11, 2001, Americans avoided flying. As a result deaths from car accidents have exceeded those from the attack. A similar mindset distinguishes delusion of the gambler from the wealth of the casino owner.

Unpredictable can not be avoided. Debates about risks

and rewards generate strong emotions that are tempered with cost-benefit analysis for accepting a level of risk. That is where experts come in the cycle of defining, perceiving and estimating risk as a part of rational decision-making. In such cases consequence evaluation is not mere calculus of probabilities. The prediction process is aided by the fact that the artificial fixed cost is generally simpler than the cost of natural uncertainty. Better understood variables of the artificial often save us only from the consequences of the unpredictable.

Terms for conclusions about future events

Anticipation: act of taking up beforehand (before the happening of the event).

Clairvoyance: ability (keen insight) to discern objects and events without sensory inputs. Often it is believed to be a power associated with mesmeric trance. Likes of Nostradamus "prediction" negatively impact public's regard for the predictive science.

Estimation: the outcome based on known variables (rough calculation of amount, value, importance; appraising or evaluating).

Forecast: to contrive an event beforehand (foresight and forethought).

Foreshadow: to indicate beforehand, prefigure, presage.

Foreshow: to show beforehand.

Foresight: An accurate view of future for the best forecast and strategy of choices

Forethought: consideration without knowledge of its significance

Judgment: to appraise events and ascertain relations from the arguments and facts (discernment, discrimination, decision).

Judgments should not violate natural laws.

Prescription: an ad hoc solution for treatment for the damage control (not cure)

Prognostication: judgment about probable course of an event (diseases, recovery).

Prediction: predicate to an inference, and thus it demonstrably relates to the intrinsic.

Projection: something that sticks out based on trends and patterns (throw forward).

Prophecy: to foretell (utterance) in any way (often claimed to be with divine guidance).

Timing the catastrophic events, like death and disease, earthquake and floods, or the stock market crash, has been of interest ever since the awareness developed that such events always occur. *Acts of god* or truly ambiguous events occur at random and out of nowhere. They happen but cannot be prevented. One can still make a calculated bet on their outcome and consequences to distribute the risks. Protection for the survivors comes at a cost that depends on whether there is a clear enough future (aging), or there are alternate (medical care) or range (education) of futures. Such wide ranging services and products (insurance, options, futures) offer protection for a risk premium. Such options are far more cost-efficient than offerings to oracles.

Forecasting weather. Uncertain outcomes are rarely driven linearly by instant cause and effect. About 4000 years ago Sumerian and Egyptian priests noticed a relationship between the position of the sun in the sky and the regularity of the rainy season that flooded the rivers to mark the sowing-season. They developed lunar and solar calendars to formalize the relationship. Such a division implied a contribution of the position of the sun to

the comings and goings of the seasons. Rulers were interested in this information to tax their subjects. For the tax collectors it introduced a predictable order for the economic stability of the agrarian societies in the flood planes of rivers where most of the population centers were located. In the leaner years some of the *benefits were trickled back* to the masses in the form of construction projects (pyramids, canals).

Star gazing: Standardization of Meaning in Regularity

There is fascination with the future whether foretold by horoscope, or prognosticated by oracles, or gleaned from precepts of wisdom. Like the seasons, the time between the death and birth could also be divided into parts (days, weeks, months and years). Use of horoscope (positions of the planets at the time of birth - a substitute for birth date before the invention of generally agreed calendar) was a logical extension of the remarkable success of the almanac (with the Arabic prefix *Al* or *the* added to the Prakrit word *manak* for the standard for comparisons) for the position of Sun, Moon, and planets in relative angular inclinations to earth at regular time intervals of day and months of moon cycle. These tables evolved into the Moon-based calendar, which were later standardized to the modern sun-based calendar now in international use.

Around 1000 years ago for the Gregorian calendar both the birthday and birth year of Christ is arbitrarily fixed. Based on the available evidence, Christ was not born on December 25, or in the year 0000 of the modern calendar. According to some estimates the birth date would be 6 years earlier around January 9.

The corrections for fixing the position of Sun in terms of the length of the day and year are quite cumbersome. The 28.4 day cycle for Moon required extensive corrections to match the daily

and yearly cycles of Sun. In the current version of the Sun-based calendar a year is divided in nearly equal 12 months of 30 days each (approximating the moon cycle). The 365.25 day yearly cycle of Sun is accommodated with 7 months of 31 days and 28 days to February. The extra quarter day is added as the 29th day to February every four year. This arrangement (to follow the angular displacement of Sun) still requires correction of a few seconds that are added to clocks around the world every few months. This standardization of the science of planetary positions has evolved over a period of 4000 years as the technology of time-keeping (*ephemeris, horaries, clocks*).

Simplification and standardization of elapsed time through convention brought an order not only to agrarian societies, but also provided a *manak* (standard measure) for all time-based dealings, events and happenings. Seasonal cycles of rain and temperature determine the time to sow and harvest. Knowledge of seasons is intricately related to survival in fertile flood plains of rivers. Even to this day, major commodity dealers have their own weather-forecasters. Understanding seasonal cycles is associated with the general well-being of all societies. Such information is useful for planning water-supply, public hygiene, transportation, and the recreational needs. Nutrition and susceptibility to diseases is intricately tied to seasons (as in the flu or allergy season).

It is no surprise that the access to the planetary positions was the purview of priestly and ruling classes whose station in life depended on the well-being of the tax-payers. *Oracle who misspoke* would probably loose daily offerings, if not more. In the absence of suitable knowledge connection of sun to weather appear far-fetched to most individuals. Therefore it is very convenient to attribute cycles of individual and collective prosperity to the

planetary cycles. It appears that a primordial fascination with the star-lit sky is still exploited by the astrological forecasts published in newspapers, magazines and internet sites to rationalize chaotic events. A well-written forecast can be justified as a psychological tonic just the same as suitably chosen kind words can be uplifting in weaker moments, and ill chosen words can be insidiously violent. Such prognostication can nudge people into action at opportune moments. Only an ardent believer would totally rely on such tools for planning the course of ones life.

Improved quality of weather prediction is a critical part of the economic prosperity. Then as now, goal of any weather related public policy is to mitigate effects of catastrophic events, such as to minimize loss of lives and damages to property. The order of weather related losses of human life in US is in the order temperature extremes, lightening, and floods. Weather related rituals and knowledge relieve people from uncertainties associated with chores of living, and not just production of food and fibers. Effects of weather are wide-spread on virtually all aspects of life. Industrial sectors that routinely rely on weather forecast include vegetable processing, off-shore oil drilling and exploration, insurance, all kinds of transportation, electric power, and emergency managements of the various kinds.

Why the weather worsens on a hike?

Most people don't start a hiking trip in a storm even though weather is almost certain to get better. Of course, this wisdom depends on the knowledge of the local weather patterns and the characteristic times. From such insights, the accuracy of hurricane tracks predicted 1 to 3 days before the event has improved in the last 30 years by a factor of 1.5 to 3. A part of this improvement is

by including more of the coastline in the prediction. The tornado warnings date only to 1948. The number of deaths from tornado in US has decreased from about 2 deaths per million of population in 1820 to about 0.1 in 1990. A similar decrease has also occurred in the lightening related deaths. Besides improved forecast other factors are communication of warnings, better housing, movement of people from rural to urban area, less time being spent outdoors.

For modifying the model for future use it is critical to monitor the effort, evaluate the outcome, provide feedback, and fine-tune. This is a general relationship for the flow of all knowledge to users in a reliable and timely manner with longer lead times.

There has been significant gain in the sciences, technologies and infrastructure that provide the basis for modeling the prediction and risk premium. Evaluation of the policy outcome in terms of the impact of such measures is difficult for a variety of reasons. For example, there is general perception that there has been significant improvement in the impact of weather forecasting along with the progress in many areas of weather predictions. The statistical certainty of predictions of models is based on the relations of wind, temperature and pressure fluctuations with the longer range patterns. Historically unprecedented events can confound the predictions and response capabilities. However the contribution of individual decision-making and compliance is still a major factor.

Taking and covering risk. Perception of the reverse relationship of good health with disease and death is innate to humans and most other higher animals. Risks are recognized as certainty in an uncertain world. Realizing that catastrophe can not be adequately predicted or averted, protection against catastrophes has been

taken to a level of sophistication, i.e. to find ways to minimize the adverse consequences. Since we may not know who will be affected and when, risk management is about minimizing the impact catastrophe on the survivors. Risks are distributed in the form of taxes, options and insurance premium. Such instruments may not be perfect they reduce the impact of vagaries of nature, including acts of God and Man, on the survivors. As ways of dealing with catastrophe life insurance does not forestall death, car insurance does not avert accidents, and health insurance does not guarantee good health.

Along similar reasoning, with an increased level of production, there is less concern for the supply of resources. Therefore, fluctuations in the supply assume greater significance for ascertaining the economic health of the system. Insights about fluctuations provide opportunities for the risk-takers and speculators of all stripes. Such instruments buffer the markets from the major catastrophes of market cycles.

Although we cannot predict precise timing of catastrophic events, the probability of such occurrences and their adverse consequences is significantly lowered by certain precautionary measures. This is the basis of the preventive health care that includes common notions about hygienic conditions as well as the life-style changes such as exercise, food, and stress-free environment. Most of these commonsense measures are free, yet people pay for cigarettes and get the risk factors in the bargain. Consider the extent to which people use the common-sense prescriptions in the rituals of food, health, habits, or choosing mate. Is the causality too distant to grasp, or are we swayed by momentum from peers or markets? To an extent social and home environment can point the way. Yet in the end, use of available knowledge and compliance is an individual decision.

There is conflict between the pros and cons of structural solutions and the individual risk-taking. Insurance and government help tend to reduce acceptance of personal responsibility for risks associated with faulty choices about location to live. For example, vastly improved flood control mechanisms have saved many lives, yet the property damage continues to increase. Publicly managed dams and levies are part of the wider water resource and wild life policies. Such projects impact on choices related to power generation, flood control measures, fisheries management, water resource allocation, and recreation. Land use and construction practices controlled by local codes also contribute. For example by permitting hog-farms in a flood prone area has caused seepage and flooding of sewage. Do we need more science or more awareness of the consequences?

Asteroid hazard

Impact-scare is the subject for movies and e-mail hoaxes. Cosmic debris hits earth's atmosphere regularly. Most of it burns away before hitting the ground. Chances of more than a kilometer wide asteroid hitting the earth's surface is once every million years or so. Last such impact possibly occurred 65 millions ago, which led to extinction of dinosaurs. The probability of such events happening within our lifetimes is exceedingly low – virtually approaching zero. Since 1600 such objects are known to be in the vicinity of earth, the possibility of the extinction of human race by such impacts is real.

Even such low probability *acts of god* could some day succumb to human interruptions. As a thought experiment, consider what steps can be taken to prevent such events in the foreseeable future, and at what cost? Prediction of potential impacts is becoming increasingly more feasible as the course of

near-earth-objects in the Space Age is routinely monitored for establishing satellite orbits. As it appears now, there are very few objects out there that could have a viable minimum orbital intersection distance with earth. Of course, the prediction of such probabilities requires highly accurate data to chart the bounds of certainty. Serious calculations to chart the course of micro-astronomical objects have been initiated.

Evaluation of the outcome. We do not always know what may actually happen. Imagine the fate of priests who divine the impending *famine or feast*. Now it is routinely done by taking long or short future positions for the gains. All forecasting exercises have differing degrees of plausibility because of their probabilistic (statistical) relationship to the underlying events. To peer through the uncertainties the forecasters (astrologers, prophets, oracles, seers, men-of religion, gamblers, futurists, experts and other talking-heads who spot market, political and social trends) have been accorded status that is commensurate with promise of the tomorrow revealed: *Sometimes the praise is not convincing and sometimes the condemnation is obviously from nowhere.*

With the realization that actions have immediate and future consequences, key elements of a policy outcome with a view of the future include prediction, communication, and evaluation. The advantage of using more transparent technologies for predictions is that the blame can be shifted from the expert to the model or inadequate data. For valid predictions worthy of a reputable profession, even in a perfectly deterministic world one needs sufficient knowledge of the fundamental variables and relations that can be quantitatively modeled. It is also necessary to have an understanding to identify and quantify uncertainties that can make the prediction meaningless. In the

context of the inputs, prediction is about knowing what characteristics of a system can make it better for decision-making.

Improving reliability of the prediction requires knowledge of all the inputs and rules of the game. The rules have to be applied correctly in the suitable deterministic context. This is nearly impossible even for a simple physical or non-living system. Scientific information on group behaviors is probability based. In the modern game-theory sense we can improve the chances of success through certain behaviors. Successes of such models attest that reliance on the reality-based facts about the situation is far more desirable than taking a pot-shot.

Like hypotheses, predictions relate to the truth value of the evidence and the knowledge base. Both guide the sound judgment and practical wisdom for decision-making by allowing us to identify relevant variables and relations for solving problems. Evaluation of risk amounts to identification of the yet unidentified variables and relations, and distinguishing these from foreordained conclusions. At least in principle, decisions based on reliable data, such as the relationship of season to a calendar, can be value free, and allow us to bypass dialog and negotiation of horse trading in establishing some of the technical merits.

Use of Imperfect Knowledge to Create a Perfect World

Science, technology and open-minded decision-making control our public and personal expectations. Such decisions have to be made with incomplete knowledge within the constraints of time. Often what is known is not always relevant to decision making, and what is needed for decision-making may not be known. Invariably, conflicts have to be overcome to satisfy very different backgrounds, motivations, and aims of the interest groups. Thus premature closing the options may deprive us of all

potential benefits of new technologies forever.

Evolution of the calendar was based on observed reality with astronomical basis in fact. The process pretty much reflects the chaotic ways in which starting with imperfect knowledge methods of science reduce uncertainties in steps. Science implies the pure pursuit of fact-based knowledge. It is collective consensus building where all conclusions remain tentative within the bounds of the data. Scientific prediction is often portrayed as a precursor to and source of objective information for rational action based on the known behavior of the real world. Miracles may happen but they cannot be trusted for charting the course of life events.

Increasingly science bears fruit of technologies in conjunction with political and market processes. So what comes out of the process bears only a superficial resemblance to the knowledge base on which the relevant science is established. In the public arena, long term consequences of a new technology for the society bear on wealth, resources, population demography, and effect on the competing technologies. Effective action need not wait until we are more certain about details, and win-now strategy. Political decision-makers include probabilistic versus categorical (individual and particular) predictions; diversity of perspectives and considering the alternatives, political will and social cost, and distribution of outcomes rather than consensus. In all contexts expertise means not just having relevant experience and knowledge, but having demonstrable competence and clear evidence to justify doing things in a certain way rather than another.

There are unknown on all sides of decision-making. Policy decisions for managing risk (warding off unfavorable or at least protection from its full impact) require elaborating details in a

complex situation (multiple variables and relations) with varying degrees of technical difficulties. Problems often border on the scientifically controversial or unknown where one can only render opinion based on what is known. Inputs are need in defining the problem, identify alternative approaches, evaluate potential solutions, and find solid answers. Experts are advisors with whom politicians have a history, an inevitable overlap of beliefs, and faith in the prediction. Thus, often the role of predictor is to change the perceptions of the decision-maker and influence policy.

Unequivocal predictions about outcome of an event, though highly desirable, are virtually impossible. For all decision-making the central issue is uncertain future, and therefore predictions are often based on unknowable unknowns. Of course, often what one does not know does matter. The cost of ignorance (or ignoring what is known) is to revisit the wrath. Rational planning is forming an intention to act on the basis of ones desires and beliefs. As a part of the wider circular relationship between science, technology and society, social cognition tends to be honest, shallow and tedious. In such contexts understanding the limitations of prediction requires an understanding of the accuracy of the data and uncertainty about the underlying relations:

1. The natural hazards happen to us. Note that many of the natural phenomena were once considered act of god, and often the plausibility was taken as provable. Such a belief did not offer any viable solution, and it prevented further investigations.
2. Sometimes we happen to nature (beach erosion, nuclear and chemical waste). In all such cases decisions have to be made – including the decision not-to-make-a-decision (inaction). What you know can hurt you!

3. Conscious decision to do something is a decision to take action and to intervene to shape future that will have winners and losers.
4. Chances are good that not all the variable have been identified. Our knowledge base for the observed behaviors is based on few decades of experience with very limited means and in very biased contexts.
5. Models are oversimplifications. Assumptions, limitations, alternatives and uncertainties in the input data should be transparent. Imperfections in the model that introduce doubt and limitations include identifiable assumptions, such as of rapid equilibrium, scaling on size and time, universal applicability and linearity of the parameter values, fudge factors and adjustable parameters, prototype, practical considerations, and the current state of knowledge.
6. Models are useful for learning structures, including learn from mistakes: Don't throw baby with the bathwater; don't disregard model on the basis of assumptions alone - observe its veracity on the basis of actual behavior; consider contingencies and exigencies.
7. Events have characteristic times. For social cognition decision-making focuses on the context for the various aspects related to the event. Events of very different characteristic times are to be approached in different ways - such as flood versus lightening. Few people have only a vague sense of slow events such as global warming, depletion of resources, impact of accumulated waste.
8. One can generate reliable information on the short-term and frequent events.
9. Three interacting factors are of interest: nature (observed event, human-impacted world), observer (scientists) and users (decision-makers).
10. Flexibility is required for a focus on good decision. Decision

makers learn from experience, question predictions, search for alternatives, and utilize the feedback by evaluating progress with respect to goals.

11. What is delivered is projection. Often predictions are not possible because the underlying science is not sufficiently developed. In the end what matters is making good decisions (not good predictions).

12. Cost of computing power versus productivity.

13. Role of the bureaucratic buffer between science and policy. It is clear that these questions are addressed to differing degrees of success. Some emergencies require short-term adjustments, whereas others raise complex policy dilemmas that are international in scope (petroleum resources, acid rain, climate changes).

Camel is a horse conceived by a committee. Governments and other public bodies routinely use expert advice for decision-making. If experts agree, their united qualified opinions set the foundation for the future course of the decision-making. If they disagree, they can find a common ground for the advisability of the future course of action. In all cases, the task is to distinguish the types and levels of advice and the expertise (knowledge base) behind it. Unlike most other types of advisors who advocate a particular course of action, experts also base their arguments on the assumptions built into a general knowledge base. Limitations of the experts include pretence or at least a sense of omniscience. Also the experts are not accountable to mass-media, public-opinion, or other forms of checks and balances.

Experts are likely to assess scientific and technological risks and evaluate the cost of a well-defined problem by asking: what is the problem? Who knows what about the problem? What is the information to be used for? How is the advice to be

institutionalized? One can guard against overconfidence by seeking advice from sources near the cutting-edge and can impart the uncertainties involved. The liabilities built into expert-opinions are often less serious of a problem than those in many other forms of inputs in the democratic process, such as the ad hoc decisions of elected officials, free markets, plebiscite, lobbying, or direct referenda. If carried out without too much external interference, such forms of public involvement open the process to the sources outside the decision making bodies.

The producers of knowledge funded through public money and the consumers of the technology in the society at large interact in a diffuse environment with conflicting undercurrents. From the nature of the inquiry through the expert advice, it is clear that the producer-consumer approaches of the market place often become more difficult when the problem is less clearly defined, or if there are multiple and conflicting sources of advice or political interests to capture the problem and associated resources. In addition, absence of knowledge may well exclude certain groups from participation. Openness of the proxy advocacy and well-balanced social values and theories is often useful for looking after the needs of the consumers of knowledge.

In short, desirable elements of expert advice include answers to questions that can sway a decision maker (user) by addressing risks and uncertainties inherent in any prediction. Such information is used to set policy goals, impact on the society, effects of predictions on the policy process, and the effectiveness of implementations. Objective predictions are not only the source of reliable information but also the first line of defense against political backlash. Interest groups hijack such political and market processes.

Room for Doubt

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