Better Angels of Our Nature. Risk Analysis, 2012; 32(7):1270–1272.

2. Roh S. Review of Nate Silver, The Signal and the Noise. Risk Analysis, 2014; 34(2):396–398.

3. International Risk Governance Council, Improving the Management of Emerging Risks: Risks from New Technologies, System Interactions, and Unforeseen or Changing Circumstances, Geneva, Switzerland, 2011. Available at: http://www.irgc.org/IMG/pdf/irgc_er2conceptnote_2011.pdf, Accessed on October 20, 2013.

4. Ellsberg D. Risk, ambiguity, and the savage axioms. Quarterly Journal of Economics, 1961; 75(4):643–669.

5. Phimister JR, Bier VM, Kunreuther HC (eds). Accident Precursor Analysis and Management, Washington, DC: National Academy Press, 2004. Available at: http://www.nap.edu/catalog.php?record_id=11061.

6. Raiffa H. Decision Analysis: Introductory Lectures on Choice Under Uncertainty, Reading, MA: Addison-Wesley, 1968.

7. Clemen R. Making Hard Decisions: An Introduction to Decision Analysis. Belmont, CA: Duxbury Press, 1990.

8. Howard RA. Decision Analysis: Applied Statistical Decision Theory, Proceedings of the Fourth International Conference on Operational Research, 1966. Reprinted in: Howard, RA, Matheson JE (eds). Readings on the Principles and Applications of Decision Analysis. Menlo Park, CA: Strategic Decisions Group, 1989.

9. Howard RA. The Foundations of Decision Analysis, IEEE Transactions on Systems Science and Cybernetics, SSC-4, 1968. Also reprinted in Howard and Matheson, eds., 1989 (see Ref. 8).

The Signal and the Noise: Why So Many Predictions Fail—But Some Don't by Nate Silver, New York Penguin Press. 2012

Reviewed by Sungjong Roh*
Cornell University

> Prophesy is a good line of business, but it is full of risks.—Mark Twain

> Human beings have an extraordinary capacity to ignore risks that threaten their livelihood, as though this will make them go away.[1]

Nate Silver's book is a must-read for risk analysts. It is well written, charts his personal career and learning experiences, and is a good reference and teaching aid for risk analysis. Silver covers a wide range of applications of statistics and prediction. His prose is clear and accessible to nonspecialists. Silver writes from experience: he has been a player in several of the fields he writes about, such as poker beginning in the early 2000s. His blog, FiveThirtyEight-DotCom, has a large following and has recently left the *New York Times*, relaunching with ESPN. *The*

*Address correspondence to Sungjong Roh, Cornell University, Department of Communication, 212 Kennedy Hall, Ithaca, NY 14853, USA; sr767@cornell.edu.

Signal and the Noise was chosen as the best 2012 book in the nonfiction category by Amazon's editors.[2]

The book focuses on forecasting and prediction, which are key components of risk analysis. It also analyzes how (mis)prediction plays a key role in risk management. The chapters cover financial risks (e.g., recent financial crisis and sports betting), health and environmental risks (e.g., the spread of infectious diseases, global climate change, and weather forecasting), and catastrophic risk (e.g., terrorism and full nuclear core meltdown).

The book consists of 13 chapters. The first half of the book analyzes problems with predictions. The three chapters after the Introduction illustrate recent prominent prediction failures (e.g., electoral forecasts, the financial crisis of the late 2000s, and baseball). Chapters 4–7 address "dynamic systems," which increase the overall complexity and difficulty of making effective and accurate predictions. After showcasing various failures and difficulties in prediction, the author turns to solutions.

The second half of the book is Silver's guide to Bayesian forecasting methods. Chapters 8–10 explore Bayes's theorem and apply it to predictions in sports, chess, and poker. Chapters 9–12 address issues more germane to human survival and well-being, such as global warming, terrorism, and financial market bubbles and crashes. The author describes several compelling real-world cases. He analyzes the September 11 attacks in 2001, the financial crisis in 2008, and flu predictions in 2009. His more distant historical examples include the December 1941 attack on Pearl Harbor and the disintegration of the Soviet Union. These examples vividly illustrate the perils of failed forecasts.

Silver describes his own successes in prediction using the metaphor of the differences in decision making utilized by the fox and the hedgehog.[3,4] Silver admires the fox for its ability to take multiple approaches to a problem and finds the hedgehog too stubborn, overconfident, and ideological to learn from its mistakes.

The author identifies three main principles: (1) *probabilistic thinking*—to craft a range of plausible outcomes instead of selecting one, (2) *course correcting analysis*—to update a prediction as newer and more valid information becomes available, and (3) *consensus*—aggregate or group forecasts are more accurate than individual ones, applying multiple viewpoints toward a problem. In addition, the author articulates the importance of weighing different

types of information together, utilizing both qualitative and quantitative information.

This is a timely book. In the age of big data, the book charts a counterintuitive course introducing what might become known as "Silver's dilemma": the signal-to-noise ratio falls as information grows. More data and information are a mixed blessing: risks arise as information growth outpaces people's capacity to process it. A useful historical case is Gutenberg's printing press innovation, which widely disseminated information, bringing about vast increases in knowledge but also facilitating centuries of religious dispute and warfare. With the printing press, people could more easily spread their own opinions, leading to greater polarization and sectarianism. The author argues that the plethora of information in the current information or computer age is also a mixed blessing.

The fundamental premise of the book is that failures in prediction have several elements in common from both sociological and psychological viewpoints. From a sociological perspective, experts can devise predictions to support their own interests, making it difficult for the public to discern the correct signal. (This can be seen clearly from Tetlock's work on the poor predictive power of political pundits. Experts in this realm who are strongly entrenched in one ideological camp provide predictions that are actually noise.)

From a psychological perspective, well-known heuristics and biases[5–7] limit our natural ability to correctly discern the signals or understand predictions. "[O]ur brains, wired to detect patterns, are always looking for a signal, when instead we should appreciate how noisy the data is."[1, p. 63] The author also highlights the inclination of people to see what they want or expect (motivated reasoning, confirmation bias). These ideas are consistent with key advances made in risk perception and risk communication almost two decades ago.[8]

Although the book identifies and analyzes failures in forecasting and prediction, it also discusses examples of success and improvement, such as advances in hurricane track forecasting. Experts can now provide communities with forecasts up to 72 hours in advance of hurricane landfall and movement, with an average miss of 150 miles, useful for evaluating evacuation options. Predictions made more than 20 years ago had an average miss of 350 miles and much less advance warning.

The book provides useful lessons for practitioners of risk communication, consumers of risk messages, and government and industry experts interested in improving their risk management and communication effectiveness. For example, forecast information alone is not sufficient to prevent losses and manage risks. It must be carefully communicated to other experts and the public, while acknowledging the margin of error and uncertainties in forecasts.

Thus, in the 1997 flood of the Grand Forks River,[9] in the months prior to flooding, the U.S. National Weather Service (NWS) issued a prediction that the waters of the Red River would rise and crest to 49 feet, only 2 feet below the height of the levee. Residents knew of an impending increase in river levels given the high levels of snowfall in the Great Plains during the preceding winter months. Unfortunately, the rising waters crested at 54 feet, causing the destruction of 75% of houses and resulted in an evacuation of 50,000 people from Grand Forks, ND and East Grand Forks, MN. To put these numbers in perspective, this was the largest displacement of people in the United States prior to Hurricane Katrina. In retrospect, the prediction was accurate but was not acted upon because the public had not been informed about the margin of error. The forecasters knew that the margin of error was ±9 feet, meaning that a significant risk existed for the flood waters to top the levee; they, however, chose not to disseminate the information for fear that the populace would lose confidence in the forecasts if they conveyed uncertainty in the outlook. Even though the flood event was quite severe locally and regionally, much of the loss could have been avoided or mitigated in real time (Silver notes that the NWS now recognizes the importance of communicating the uncertainty in its forecasts).

A great strength of the book is its 56 pages of notes providing explanations, citations, and web links, so that readers can follow up in areas of their interest. An unfortunate weakness is the number of mathematical mistakes, miswordings of text, and misplacement of information in tables and figures, which may confuse a careful reader.

The Signal and the Noise is an ambitious and excellent book. It makes a solid contribution in the field of prediction, fully analyzing why predictions often fail and highlighting the importance of Bayesian reasoning to discipline our thinking and modeling. The author uses a highly transparent style, illustrating his points with a wide array of modern and historic examples. This reviewer can forecast that the book will be valued by risk analysts based on the signals detected from his reading.

ACKNOWLEDGMENTS

REFERENCES

1. Silver N. The Signal and the Noise: Why So Many Predictions Fail But Some Don't. New York Penguin Press, 2012.
2. AmazonDotCom. Best Books of the Year: 2012 Editors' Pick. Editors' Picks by Category. Available at: http://www.amazon.com, Accessed on October 20, 2013.
3. Tetlock PE. Expert Political Judgment: How Good Is It? How Can We Know? Princeton, NJ: Princeton Press, 2005.
4. Berlin I, Hardy H. The Hedgehog and the Fox: An Essay on Tolstoy's View of History, 2nd ed. Princeton, NJ: Princeton University Press, 2013.
5. Kahneman D. Thinking Fast and Slow. New York: Farrar, Straus and Giroux, 2011.
6. Slovic P. Perception of risk. Science, 1987; 236(4799):280–285.
7. Tversky A, Kahenman D. Judgment under uncertainty: Heuristics and biases. Science, 1974; 185(4157):1124–1131.
8. Fischhoff B. Risk perception and communication unplugged: Twenty years of progress. Risk Analysis, 1995; 15(2):137–145.
9. USGS. The History of Flooding in the Red River Basin. Available at: http://pubs.usgs.gov/gip/2007/55/pdf/finalWebGIP55.pdf, Accessed on September 6, 2013.