the review of income and wealth

Review of Income and Wealth
Series 62, Number 4, December 2016
DOI: 10.1111/roiw.12198

RESIDUAL RISK ACCOUNTING: A PILOT STUDY

by Scott Farrow*

UMBC and the Woods Hole Oceanographic Institution

Risks such as flooding, oil spills, deaths, and unemployment continue despite numerous policies to prevent and mitigate their effects. Such policies are typically analyzed in their natural units such as jobs making comparison difficult across categories. An approach akin to a satellite national income and product account (NIPA) allows direct comparison of the relative importance and variability of these residual risks. Results are presented for an unusual geographic aggregate associated with coasts. Although this framing adds difficulties for integration into national accounts, precedents exist. The findings synthesize elements that would otherwise be separated or not reported in standard NIPA accounts. Some elements are found to be stable and large, while other elements exhibit high variability and a high level of damages potentially informing individual and policy choices. The pilot case study also suggests the value of using a more standard, national geographic area.

JEL Codes: E01, D60, Q00

Keywords: flood, NIPA, risk, unemployment, VSL

1. Introduction

Economic accounting focuses on the production of goods and services and income. However, policy often focuses on negative outcomes such as unemployment, mortality, and damages which are collectively referred to as risks. Risks are often discussed and analyzed in their natural units and are generally not measured in a common monetary metric. The monetary effect of a risk that occurs can be widely spread throughout economic accounts and some dimensions of a risk may not appear at all. While not without controversy, monetizing normally incomparable risks can facilitate comparison, regulatory design, and causal modeling of the risks. Such infrastructure building and facilitation is the purpose of this illustrative study.

In the market economy, the National Income and Product Accounts (NIPA) have a long history of accounting for economic activity (Berndt and Triplett, 1990). The National Research Council (1999, 2005) has reported on the usefulness of expanding NIPA to include satellite or supplements to the core accounts. The potential applications for such satellite accounts appear broad when the accounts are defined as "Supplemental accounts that expand the analytical capacity of the

Note: Appreciation is extended to the U.S. Coast Guard and the U.S. Bureau of Labor Statistics for data, and for comments to the audiences at the 2013 Society for Benefit–Cost Analysis conference, the U.S. Coast Guard and the Woods Hole Oceanographic Institution, and to an anonymous referee. Fellowship support was provided by the Marine Policy Center of the Woods Hole Oceanographic Institution.

*Correspondence to: Scott Farrow, UMBC, 1000 Hilltop Circle, Department of Economics, Baltimore, MD 21250, USA (farrow@umbc.edu).

main system of accounts by focusing on a particular aspect of economic activity. Satellite accounts are linked to the main accounts but have greater flexibility in providing more detailed information or in using alternative definitions, concepts, and accounting conventions" (BEA [Bureau of Economic Analysis], 2014). Such supplemental accounts are not a complete, integrated alternative to the NIPA such as those suggested by Jorgenson *et al*. (2006), Nordhaus and Tobin (1972), and Daly and Cobb (1994) or the extended issues that the social indicators movement has considered (Cobb and Rixford, 1998).

The residual risk series developed here are neither an industry specific supplement nor a complete alternative. Instead, the data series to be developed use alternative definitions and conceptually integrate data which can appear in disjoint NIPA accounts or not at all. This pilot study defines its scope using subjectively identified policy relevant residual risks in the coastal zone. This framing adds some complexity due to separate conceptual issues that arise in each risk subject area and by considering a sub-national geographic area. Other complexities are reduced by not considering the potential universe of risks in a national setting. The residual risk series can also be considered an expansion across risk categories related to research by Muller *et al*. (2011) which focused on air pollution, an outcome which is more easily associated with a limited number of industries. Ultimately, the analysis here is about monetized residual risks and the potential usefulness of that concept. The coastal focus serves merely to limit the pilot effort, although some analysts may find it of interest in its own right and a history of NIPA application to the coastal area exists (Pontecorvo *et al*., 1980; Monterey Institute, 2013).

The onshore and offshore coastal environment is an illustrative portion of society and the larger economy as numerous uncertain events occur. Undesirable events, whether variability in good outcomes or what are generally considered bad outcomes, are identified as risks which numerous policies seek to prevent, mitigate, or transfer. Existing policies include those designed to prevent flooding, oil spills, and drowning deaths. Other policies seek to encourage the transfer of financial risk through insurance against flood damage and unemployment. Debates about such policies often focus on the natural units of these risks such as unemployment, fatalities, oil spilled, and damages to the built infrastructure. Without a common unit of measurement, it is difficult to compare and contrast such risks except by subjective ranking, an approach used by the U.S. EPA (1987), although that approach loses information about the absolute level of risk.

Importantly, risks may or may not be worth reducing based on economics. The benefits of an activity may be large (and are not investigated here) or the costs of risk reduction may be larger than the cost of the risks themselves. As will be discussed in a section on uses of the analysis, these monetized risk series allow comparison in the level of dollars across risks and provide an estimate of the maximum potential benefit from a risk reduction program, but they do not themselves indicate that the risks are "too high," "too low," or "just right."

While many risks are not traded in markets and so have no obvious marginal price, the tools of benefit–cost analysis can be applied to estimate a "shadow price" or marginal value as if a market existed. A large body of literature exists on general principles for developing these shadow prices, as well as specific examples such as the value of a statistical life (Farrow and Zerbe, 2013). These shadow prices and

the quantities to which they are applied contrasts with the more normally traded elements of economic activity as are reported in NIPA or for the U.S. coastal sector by the National Ocean Economics Program (Monterey Institute, 2013). Importantly, the monetary impact of a realized risk may be partially observed in some NIPA accounts and partially not observed in the accounts. For instance, "normal" damages from floods are part of the definition of insurance services but actual insurance payments appear as transfers between the appropriate parties. Uncovered damage from floods may, or may not, entirely appear in NIPA categories related to business activity and lost imputed rental value of owner occupied housing (Chen and Fixler, 2003; U.S. Congressional Budget Office, 2005). Related issues are discussed in the supplemental Appendix for each specific risk.

Eight initial residual risk series are analyzed for the coastal zone: flooding, unemployment, oil spills, and five causes of fatalities—boating, swimming, occupational, hurricane, and marine weather other than hurricanes. These individual categories are grouped into the three broader categories of natural hazards, recreational, and occupational outcomes. There are numerous conceptual and empirical challenges to creating such time series so results presented here should be recognized for their limitations in data availability, varying degrees of precision in the measurement of shadow prices, and limitations in allocating events to the coastal zone. In this case, the pilot study in a limited geographic area both created and reduced some empirical challenges compared to a national level of analysis.

The paper proceeds with sections on concepts, data and estimation, results and discussion.

2. Conceptual Issues

2.1. *Which Risks?*

Risks occur too numerous to count. This analysis covers an illustrative but not exhaustive set of coastal risks for which government, especially the federal government, takes direct or indirect responsibility. While not a complete set of coastal accounts, they illustrate the variety of outcomes that might be placed in monetary terms.

Risk has a variety of meanings in the literature. From a forecasting perspective, risk is typically a probabilistic statement about an undesirable outcome in either direction or variability. From the retrospective perspective taken here, one observes the realization of the undesirable, "risky" outcome for that period and so the risk has occurred (perhaps with measurement error) and is not probabilistic in the sense of whether or not it occurred. The term "residual" thus represents the conditional risk incurred by elements of society after efforts to avoid or mitigate risk.

Individuals, organizations, and governments manage risks in a variety of ways such as avoidance, mitigation, transference, and acceptance or, in the case of Government, sometimes by imposing regulations that may mandate actions on other sectors. The residual element of risk is what occurs given the management choices which were in place at the time of measurement. Consequently, risks that are avoided or mitigated are not residual risks and do not appear in the data.

However, risks that are financially transferred are included initially in the data and then analyzed in a later section for the degree of transference.

2.2. *Whose Risks Count: The Issue of Standing*

The risk series are developed for a portion of the United States, the coast, which is not a commonly identified component of the NIPA accounts. However, there is precedent in assessing the unusual geographic and environmental composite identified as a coastal "sector." The coastal sector has been defined in different ways by previous researchers. Although the ocean is the typical common link, this "sector" contains elements both in common with other sectors and elements which are unique. For instance, Pontecorvo *et al*. (1980), in assessing the importance of the coastal sector to the national economy, defined the sector rather narrowly; while extensions of that work, such as through the National Ocean Economics Program, define the sector as either depending on the ocean or its products, or adjacent to the ocean (Kildow *et al*., 2014). Similar to Pontecorvo *et al*.'s approach, this study focuses on coastal and marine activities directly related to the marine aspects of the coastal zone. For some categories such as flooding, natural hazard deaths, or oil spills, it does not matter who incurred the risk, whether a coastal tourist or commercial fisher. However, in the risk categories linked to industry definitions, such as occupational fatalities or unemployment, more generic industries are not included, such as retail trade in the coastal zone.

Industry data come from a variety of sources, not specifically the NIPA accounts, and range from information using the North American Industry Classification System (NAICS) to unique reports prepared by federal agencies. For instance, NAICS industry definitions included in some components are: oil and gas extraction; ship building; water transportation; and fishing, hunting, and trapping. Examples of non-industry data sources are county specific claims from the National Flood Insurance Program, NOAA's natural hazard statistics, U.S. Coast Guard Boating Statistics, U.S. Lifesaving reports, the Bureau of the Census Current Population Survey, and the Bureau of Labor Statistics Census of Fatal Occupational Injuries. Data sources are identified in the supplemental Appendix along with computation methods.

In general, the data require some allocation to the coastal and non-coastal sectors. Allocation to the coastal sector was based on the activity occurring in or seaward of a coastal county as defined by the U.S. Coastal Zone Management Act (including the Great Lakes) as defined by the U.S. Census Bureau (2012). Some data sets required a cruder allocation. Consequently, the impact allocations for this study are only approximate although elements of these allocations are discussed in each individual item in the Appendix. The time period covered is from 1995 to 2010. This period was chosen as one in which few major changes in data definitions occurred and which was subjectively viewed as long enough to display elements of year to year variability.

2.3. *Shadow Prices for Risk: NIPA Data and Alternative Definitions*

Microeconomic theory links values held by individual consumers with market prices to allocate goods and services. Welfare economics and its empirical

application, benefit–cost analysis, uses marginal values to infer whether society is potentially better off from taking a policy action or maintaining the status quo (subject to several key assumptions) where a change often has a discrete effect on demand. Strongly motivated by environmental concerns, goods and services that are not traded in the market have also been incorporated into welfare economics. Numerous empirical methods exist to value activities such as coastal recreation, ecosystem services, the value of a statistical life, and other goods and services (Boardman *et al*., 2011). The term "shadow price" is often used for a non-market but marginal monetary value. In the simplest approach to benefit–cost analysis and consistent with NIPA (BEA, 1985, 2006), a change in quantity due to a policy is multiplied by its (marginal) shadow price in order to put impacts into monetary terms. Such is the approach taken here. Shadow prices existing in the literature are used to value risky outcomes in the coastal zone. Some of these prices have a long history of estimation, and continuing controversy such as the value of a statistical life (VSL) (Viscusi and Aldy, 2003; Banzhof, 2014). The VSL measures how much people value small changes in risk, such as the risk of dying from air pollution or from an accident in the workplace which is aggregated to represent the value of avoiding one statistical death. Other shadow prices, such as those for unemployment (Bartik, 2012; Masur and Posner, 2012) and oil spills (Diamond and Hausman, 1994; Carson *et al*., 2003) are less resolved in the economics literature, but substantial research and estimation has occurred as will be discussed in context.

As might be expected, important framing issues exist for shadow prices. One issue is in regard to how people value risk itself. If one wishes to estimate a shadow price in advance of the risk occurring, should one use the mathematical expectation of damages if measurable, or a measure which incorporates preferences to avoid risk such as option price, or a more behavioral approach that distinguishes gains from losses such as cumulative prospect theory? Those approaches may not be as divergent in practice as they are in theory (Farrow and Scott, 2013), but the approach taken here is to use the shadow price in standard usage for a category. Thus expected damages are most frequently used to assess floods, while an equivalency between willingness to accept and willingness to pay measure underlies the shadow price of the VSL. Similarly, debates exist about the extent of indirect effects of a risk and whether to include what are often called secondary or general equilibrium effects which result from an impact rippling through many markets. The approach taken here is that most common in benefit–cost analysis, a partial equilibrium approach which may include a number of effects, as from oil spills, although it does not pursue their effect through the entire economy where they may be thought to be de minimis.

2.4. *Uses for Residual Risk Data*

Residual risk estimates, while measuring realized costs, can inform the potential benefit of additional policies or actions which reduce the risk. Comparing these residual risks across policy areas can be a rough guide to the maximum potential benefits of budgetary and investment decisions to reduce or mitigate risks. However, knowing the actualized residual risk does not say anything about the

total benefit of activities associated with the risk (such as living near the ocean or engaging in recreational boating), or the potential costs or net benefit of any additional policy under consideration. This accounting of residual risk does not imply market failure, a "need" for a Government program, that any program targeted at such risks would be cost-beneficial or that a program has retrospectively failed or succeeded. What the risk accounting might do is to provide comparable data across risks about which such questions could be asked and which might be incorporated into more detailed causal models. The Historical Statistics of the U.S. (Carter *et al*., 2005) is just one illustration of the importance of providing credible time series data as the infrastructure for researchers to use in ways that the original data collection efforts could not have foreseen. Similarly, the originators of carbon dioxide measurements from Hawaii could not have foreseen how those data could have inspired so many other investigations and fed into so many scientific investigations about climate change.

Some external comparisons for the scale of monetized risks may be useful. In 2010, 39 percent of the U.S. population lived in coastal counties whereas those counties account for only 10 percent of the U.S. land area (National Ocean Service, 2014). Employment in industries directly related to the ocean (hence omitting retail trade in coastal counties and so on) totaled 2.8 million while GDP associated with those industries was $282 billion in 2010 (Monterey Institute, 2013). If a broader definition of coastal activity is used, the numbers increase substantially. In that context, the residual risks reported here can be seen as "small" in the context of aggregate production and employment but may provide information for incremental policies related to risk reduction.

3. Results

Estimation of the individual risk components, descriptive statistics, and data sources are discussed in the supplemental Appendix, while this section provides a synthesis of the results.

The primary results of monetizing residual risk prior to any adjustment for insurance coverage are represented by three figures. Figure 1 plots the core data on the four categories of fatalities, total flood damages, unemployment, and oil spills on the Outer Continental Shelf (see Appendix Tables 1, 2, 3 for data). The impact of flooding and hurricane related deaths in 2005 immediately stands out as a spike in the data. On closer observation the steady but relatively high level of recreational fatalities may come as a surprise to some analysts.

Figure 2 presents the shares of the expected value of damages across the categories. While costs due to flooding are clearly large in expected value, recreational fatalities from boating and swimming accidents represent close to one-third of the annual expected risk in the coastal zone as measured here. The expected values of unemployment and occupational fatalities in the identified industries, oil spills, and hurricane fatalities are similar in magnitude, with each accounting for a share between 4 and 9 percent of the aggregate value of residual risk.

Figure 3 identifies the categories with the largest variation as risk management is often concerned with both mean response and variation. Flooding, hurricane fatalities, and oil spills account for virtually the entire variability in the

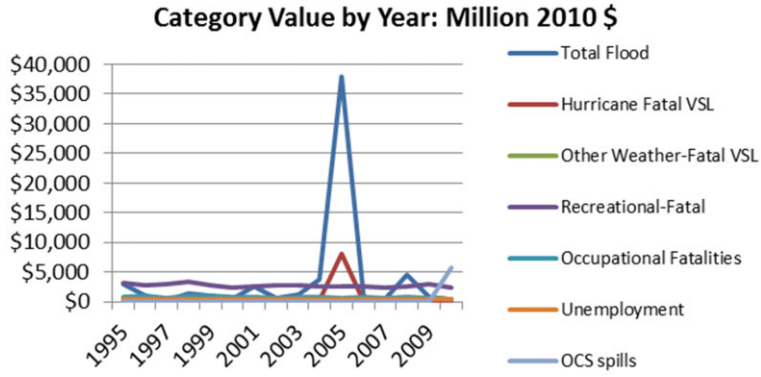

Figure 1. Time Trend of Monetized Coastal Risks: Million 2010 Dollars

Source: Appendix Tables 1, 2, 3.

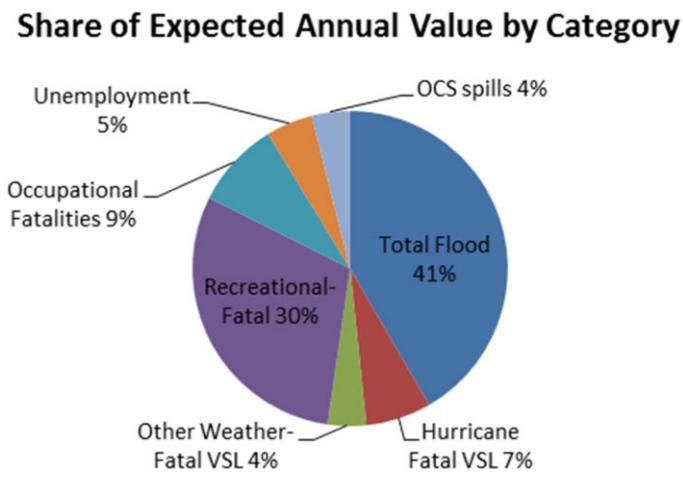

Figure 2. Annual Expected Value Shares by Risk Category

Source: Appendix Tables 1, 2, 3.

outcomes as measured by the variance of the several data series. The other categories of fatalities and unemployment are relatively stable and contribute little to the variability of coastal residual risk.

Risks such as flood damages, job losses, and fatalities occur and represent a cost to someone. However, the direct cost may be at least partially offset by transferring the risk to others as through flood or unemployment insurance or by ex-post liability regulation. Such transference has its own resource cost and distributional impact, which has been detailed for the NIPA accounts by Chen and Fixler (2003). The shadow price when insurance exists can be complex (Boardman *et al.*, 2011). In addition to insurance, liability may be assigned, as for oil spills, such that those initially incurring costs are intended to be compensated for their loss. Consequently, although the preceding tables do not account for insurance, they do represent economic measures of risk prior to any distributional effect

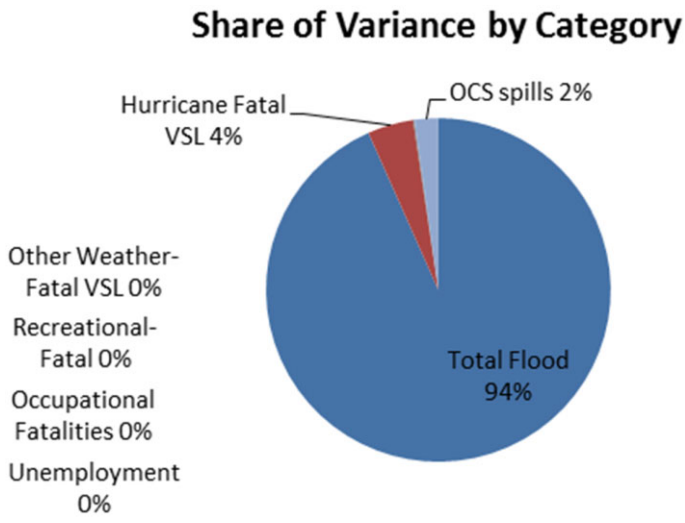

Figure 3. Variance by Risk Category

Source: Appendix Tables 1, 2, 3.

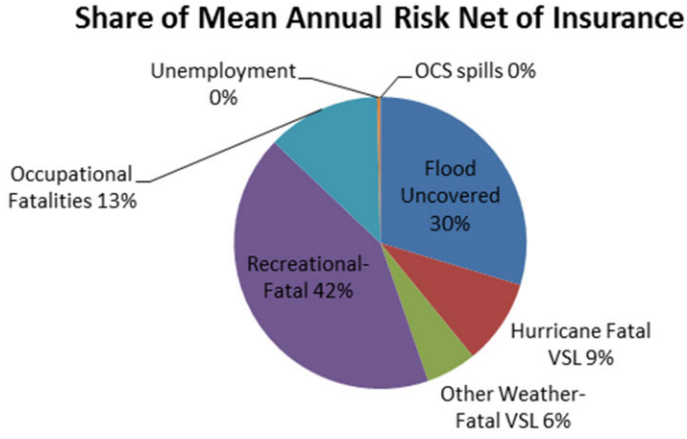

Figure 4. Annual Risk Categories, Net of Insurance and Liability

Source: Appendix Table 4.

resulting from insurance or liability coverage. Nonetheless, policy makers may be interested in the extent of monetized but uninsured risks.

The effect of insurance and ex-post liability coverage has a dramatic impact on the direct expected annual losses as can be seen in Figure 4. For instance, the uninsured portions of flooding and recreational deaths have similar annual expected shares of the total risk cost. The expected shares of oil spills and unemployment after insurance are reduced to close to zero. The exact value of these results can be disputed, but the existence of risk transfer policies clearly has a larger impact on some categories than others. A chart of the share of the variance

for the insurance and liability adjusted series would show that flooding and hurricane fatalities accounted for almost all the variability. In contrast to Figure 3, the variability due to oil spills becomes negligible due to the assignment of liability.

4. Summary and Directions for Further Research

Major residual risks are analyzed in comparable terms for the coastal zone. Monetization of previously non-comparable categories yields insight into both the relative level and variability in the outcomes. Recreational fatalities are revealed to be a relatively large source of risk in the coastal zone but with very little variation. In contrast, flooding is revealed to be large, with respect to both its annual expected risk and its variability. Risks such as unemployment, occupational and hurricane fatalities, and oil spills represent similar shares of the average coastal risk but the variability of these risks is quite different. Risk transfer as from insurance and liability does not change damage from the risks, but shifts it to an identified party such as those who pay flood and unemployment claims, taxpayers, and those parties who are liable for specific oil spills. Insurance and liability adjusted data reduce the direct importance of flooding, unemployment, and oil spills while having little effect on fatalities.

The absolute and relative magnitude of these accounts is importantly influenced by both the geographic definition and the substantive definition of activities related to the coastal and marine environment. For instance, a broader definition of coastal unemployment might include dining and lodging establishments which would expand the importance of that category without a concurrent expansion of damages such as those due to flooding. Some data are missing, such as unemployment data for self-employed fishers. Except for flooding, somewhat less data are available for annual elements of insurance coverage.

More generally, further research may most appropriately analyze residual risks on a nationwide basis and using a broader set of risk outcomes. Examples of additional, nationally important risk categories might include, but not be limited to: (1) dropping out with less than a high school education, (2) early age pregnancy, (3) poverty, (4) premature mortality due to various disease and other accidental causes, (5) crime, and (6) environmental damages. The framework of residual risk accounting illustrated here could allow cross-category comparisons based on the monetization of impacts, although many of these risks are not closely identified with one or a few industry classifications in the standard NIPA accounts. However, monetized risk data could, like NIPA data, provide the infrastructure to investigate numerous economic and policy questions.

References

Banzhof, S., "The Cold War Origins of the Value of a Statistical Life," *Journal of Economic Perspectives*, 28, 213–26, 2014.

Bartik, T. J., "Including Jobs in Benefit–Cost Analysis," *Annual Review of Resource Economics*, 4, 55–73, 2012.

BEA (Bureau of Economic Analysis), U.S. Dept. of Commerce, "An Introduction to National Economic Accounting: U.S. National Income and Product Accounts," MP-1, Washington D.C., 1985 (www.bea.gov/articles/national/nipa/methpap/methpap1.pdf).

———, "Updated Summary to NIPA Methodologies," Washington D.C., updated September 2006 (http://www.bea.gov/bea/an/nipaguid.pdf).
———, "NIPA Handbook: Concepts and Methods for the US National Income and Product Accounts," November 2014 (http://www.bea.gov/methodologies/index.htm#national_meth).
Berndt, E. and J. Triplett, "Fifty Years of Economic Measurement," National Bureau of Economic Research, Studies in Income and Wealth, Vol. 54, University of Chicago Press, Chicago, IL, 1990.
Boardman, A., D. Greenberg, A. Vining, and D. Weimer, *Cost-Benefit Analysis*, 4th edition, Prentice Hall, Upper Saddle River, NJ, 2011.
Carson, R., R. Mitchell, M. Hanemann, R. Kopp, and P. Rudd, "Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill," *Environmental and Natural Resource Economics*, 25, 257–86, 2003.
Carter, S., S. Gartner, M. Haines, A. Olmstead, R. Sutch, and G. Wright (eds) (S. Farrow, co-ed, Environment), *Historical Statistics of the United States*, Millenium Edition, Cambridge University Press, Cambridge, 2005.
Chen, B. and D. Fixler, "Measuring the Services of Property-Casualty Insurance in the NIPAs," *Survey of Current Business*, October, 10–26, 2003.
Cobb, C. and C. Rixford, "Lessons Learned from the History of Social Indicators," Redefining Progress, 1998 (www.redefiningprogress.org/newpubs/index.shtml).
Daly, H. and J. Cobb, Jr., *For the Common Good*, 2nd edition, Beacon Press, Boston, MA, 1994.
Diamond, P. and J. Hausman, "Contingent Valuation: Is Some Number Better than No Number?" *Journal of Economic Perspectives*, 8(4), 45–64, 1994.
Farrow, S. and M. Scott, "Comparing Multi-State Expected Damages, Option Price and Cumulative Prospect Measures for Valuing Flood Protection," *Water Resources Research*, 49, 2638–48, 2013.
Farrow, S. and R. Zerbe (eds), *Principles and Standards for Benefit–Cost Analysis*, Edward Elgar, Cheltenham, 2013.
Jorgenson, D., S. Landefeld, and W. Nordhaus, *A New Architecture for the U.S. National Accounts*, University of Chicago Press, Chicago, IL, 2006.
Kildow, J., C. Colgon, and J. Scorse, "State of the US Ocean and Coastal Economies," National Ocean Economics Program, 2014 (and earlier annual reports) (http://www.oceaneconomics.org/Download/; accessed February 26, 2015).
Masur, J. and E. Posner, "Regulation, Unemployment, and Benefit–Cost Analysis," *Virginia Law Review*, 98, 579–634, 2012.
Monterey Institute, Center for the Blue Economy, "National Ocean Economics Program," 2013 (http://www.miis.edu/academics/researchcenters/blue-economy/noep; accessed January 11, 2013).
Muller, N., R. Mendelsohn, and W. Nordhaus, "Environmental Accounting for Pollution in the United States Economy," *American Economic Review*, 101, 1649–75, 2011.
National Ocean Service, "Population," 2014 (http://oceanservice.noaa.gov/facts/population.html).
National Research Council, Committee on National Statistics, Panel on Integrated Environmental and Economic Accounting, W. Nordhaus and E. Kokkelenberg (eds), *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment*, National Academy of Sciences, Washington D.C., 1999.
———, K. Abraham and C. Mackie (eds), *Beyond the Market: Designing Non-Market Accounts for the United States*, National Academy of Sciences, Washington D.C., 2005.
Nordhaus, W. and J. Tobin, "Is Growth Obsolete," in *Economic Research, Retrospect and Prospect, Vol. 5: Economic Growth*, Columbia Press, New York, 1972.
Pontecorvo, G., M. Wilkinson, R. Anderson, and M. Holdowsky, "Contribution of the Ocean Sector to the United States Economy," *Science*, 208, 1000–06, 1980.
U.S. Census Bureau, "Identification of Coastal Counties" (http://www.census.gov/geo/landview/lv6help/coastal_cty.html; accessed August 8, 2012).
U.S. Congressional Budget Office, *The Macroeconomic and Budgetary Effects of Hurricanes Katrina and Rita*, Washington D.C., 2005.
U.S. EPA, "Unfinished Business: A Comparative Assessment of Environmental Problems," 1987 (http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000BZOP.txt).
Viscusi, W. K. and J. Aldy, "The Value of Statistical Life: A Critical Review of Market Estimates throughout the World," *Journal of Risk and Uncertainty*, 27(1), 5–76, 2003.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix: Data sources with annual results and descriptive statistics