22.

STATE OF THE FUTURE INDEX (SOFI) METHOD

By

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1. HISTORY OF THE METHOD

The State of the Future Index (SOFI) is a quantitative time series that indicates the changing state of the future and shows whether conditions promise to get better or worse. A description of the method and its first applications appeared in the State of the Future, 2001 and 2002 reports of the Millennium Project of the American Council for the United Nations University. The 2003 report will include the third example of the process. These publications summarize the results of a three-year research program in which judgments were collected from a worldwide panel that asked for opinions about the elements that should be included in such an index, and, for the selected subset, the best and worst expectation for the next ten years.

II. DESCRIPTION OF THE METHOD

Indexes have been constructed in the past to aggregate many factors into a single number that depicts the general state of affairs in a variety of areas. The cost of living index, for example, combines the cost of food and other consumer goods in a standard "market basket" to show how prices are changing. The Dow Jones Industrial Average aggregates the price of stocks of selected firms to create a number that quantifies the aggregate state of certain stocks on the New York Stock Exchange. Indexes such as these have very stringent quality controls applied to the data and computational processes.

The intent of the SOFI is to combine variables that indicate whether future conditions seem to be getting bettor or worse, to form an overall indicator of the state of the future. It is true that polls could be conducted to obtain public perceptions about the future outlook (e.g., "Do you think things are likely to get better or worse?"), but such surveys are subject to recent news and media pressures, and people answering may discount or not know about recent improvements or threats.

SOFI is similar to other indexes since it combines many variables into a single measure The SOFI differs from other indexes in several important respects. Most indexes are concerned with the present or past, the SOFI is designed to measure the promise of the future. Most existing indexes are cross-sectional and are designed to compare countries to countries or various groups of countries at some point in time (usually the most recent possible). SOFI is longitudinal and is designed to track and project change over time. While a SOFI contains variables that might also appear in an hypothetical Quality of Life Index, it contains many others as well and it focuses on the future state of the variables

In addition, the SOFI application published in 2001 is also unique in that it was derived from suggestions of the Millennium Project Global Lookout Panel in 1999-2000 which recommended and rated indicators to measure progress or regress on the 15 global challenges tracked by the Project. Then in 2001 a special Global Panel rated indicators for the SOFI in terms of their normative and dystopic levels and priorities. 57 participants from about 15 countries participated in this SOFI panel. The process involved collecting judgments about the variables that might be included in the index, weighting of the variables, and perceptions about the best and worst possibilities for each variable, all judgments involved in calculating the index. Further, the

process involved feedback that allowed respondents to add to and reassess the judgments, which they and others provided in earlier global outlook panels. An excerpt from this questionnaire appears in Appendix A. .(Note that the questionnaire lists some 49 variables as candidates for the SOFI; ultimately 19 were used. The culling was done to eliminate redundancy, on the basis of perceived importance, and availability of data.)

In SOFI, selected variables are forecasted and combined into a single measure. If the outlook of the future seems to be changing, then the SOFI would make it clear how, and the index would make it possible to identify the factors responsible. If confidence were developed in such an index, it could be used for policy purposes: plans could be evaluated and compared on the basis of their impact on a State of the Future Index.

One of the reviewers of this paper said:

> *If properly communicated, SOFI (could) become a reference and play a role in shaping the future. In this ultimate step, the SOFI surpasses its function of passive measurement to become an award for good and bad achievements, thereby contributing to changing significantly the behavior of the key actors.*

III. HOW TO DO IT

Building a State of the Future Index requires the answer to five questions:

1. What variables should be included in a State of the Future Index? If people say that the future seems promising, what do they mean? That life will be good for themselves and their family; that food, water and shelter will be sufficient; that fear will be absent and life fulfilled. What else should be included? The selection of variables forces a person to answer two key questions: What do I consider an improvement? And how would I know it if it happened?

2. How can very different variables be combined? It is necessary to make all the measures included in the SOFI commensurate—that is, expressed in terms that are comparable. A key value of this methodology is that it permits the compilation of indicators of completely different origins and meanings into a single index.

3. How can the variables be forecast? Measurement is not enough; since we are dealing with the future, the elements of the SOFI must be forecast. How can this be done?

4. How can the variables be weighted? The SOFI elements are not all of equal importance to the future; the SOFI uses the concept of nonlinear weighting in order to balance the significance of the measures that are included. But weighting leads to other problems: different people may see one or the other of the measures as being more or less important, or even of different polarity—that is, some may see an increase in a variable as good while others see it as bad. Since the SOFI is designed to be an aggregated measure, it can mask differences among groups or nations: the SOFI could look very positive and yet for some groups or nations, the situation could be worsening. Therefore it is important to recognize that disaggregated SOFI analyses will be

essential so that groups or nations can determine—using their own data and weights—how things seem to be changing.

5. How can double accounting be avoided? This has to be considered or else one area could be over-represented. For example, should SOFI include both a measure of carbon dioxide concentration and global temperature? They measure different things but are important to consider for the SOFI for the same reason.

What Variables? In the prior research, the SOFI indicators were selected through a series of international questionnaires and refined through a review of index studies[1]. Other approaches might be used, of course: in a corporate setting the variables might be selected by a committee. No matter what the technique, in the aggregate the variables selected have to represent the key elements of the question the Index is designed to address. In the case of SOFI: does the future seem to be getting better or worse? For the corporation, the question might be identical, but the variables selected would be quite different.

Combining the variables. In our approach we let the best possible value for the variable equal 100 and the worst, zero. The value of the variable was expressed as a percentage of this range. We asked our Global Lookout Panel to provide judgments about what the best (norm) and worst (dystopic) status was for each nominated indicator in 2011. These are, in fact, scenario-like assumptions about how the future may evolve.

Forecasting the variables. In the first uses of SOFI, the variables were forecasted using simple curve fitting techniques; in later applications, Trend Impact Analysis (described elsewhere in this volume) was used. In both instances twenty years of historical data were collected and provided the basis for the forecasts.

Weighting the variables. Our Global Lookout Panel not only provided judgments about the anticipated best (norm) and worst (dystopic) value of each variable, they also rated the importance of reaching the norm and dystopic state. The criteria for assigning a high weight to a variable were: the number of people affected; the significance of the effect; whether some groups seem to be affected differentially; the time over which the effect will be felt; and whether the effect is reversible.

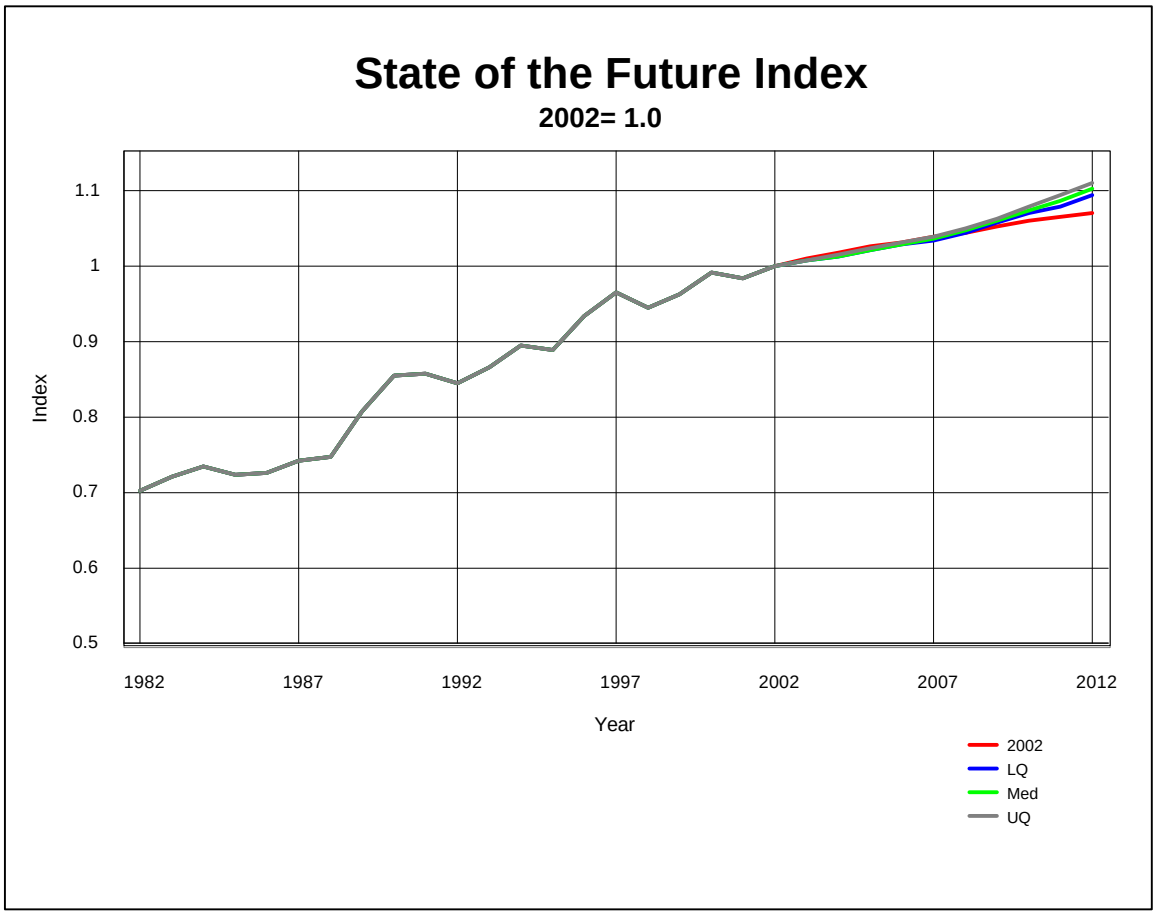
The variables were weighted in a novel way. All indexes studied thus far have assumed that weights are constant (and usually sum to unity) and independent of the value of the variable they modulate. Instead, SOFI assumed that the weights assigned to some indicators should change as the values of the indicators rise and fall. When an indicator reaches a level of satiation, it may not be as important as it used to be. For example, when the level of food intake is below 1500 calories per person, the variable is very important. When it is above 3000, the sense of urgency associated with hunger no longer gives this variable much weight.

To accommodate this nonlinearity, an S-shaped function was developed that allows the weight of a variable to vary with the value of the variable.

[1] Glenn and Gordon, op. cit.

Double accounting. There is no formula for removing redundancies; it requires careful thought and examination of the definitions of similar or overlapping variables. This is particularly difficult if two variables are similar in most respects but differ only in nuance. Nevertheless, this step is essential and ultimately relies on judgments of the analysts to choose variables that best capture the essence of the problem being addressed.

The figure below presents the results of the 2003 SOFI exercise.



The curve could be analyzed to find reasons for past growth, the cause for dips and valleys, and the reason why the curve changed slope in the near future.

IV. Conducting a SOFI Analysis

The Millennium Project has completed two SOFI exercises; these are reported in State of the Future 2001 and 2002. A third analysis is planned for 2003.

This section describes the process that might be followed by an organization considering repeating the exercise for a particular region or institutional purpose, such as a country-specific

SOFI depicting the future outlook for the country to be compared with the global SOFI or with other countries, or a corporate SOFI depicting the future expectations for a firm.

Task 1. SOFI Selection of Variables, involves the choice of time series that might be considered as components of the SOFI. The set used in the Millennium Project could be a starting point for a country and could be validated in a two-round questionnaire to be sent to 50 or more participants. The persons invited to participate should be selected on the basis of prior publications in the field, positions in decision making, recommendations by professional societies, etc. The questionnaire should ask, in effect, what variables ought to be included in an index that depicts the state of the future. The questionnaire should also ask for the best anticipated value of each of the variables in the time period of interest and the worst plausible value—these values will be used in normalizing the value of the variable when it its aggregated into the index. The questionnaire should also ask for the weights that should be applied to the variables at the norm or dystopic extremes. Finally, participants should be asked to provide source information where data might be obtained for variables they recommend.

Task 2. SOFI Data Collection, involves the collection of time series data for the variables that are to be included for the index. Ideally, 20 years of annual historical data will be required. In selecting the variables, one ought to be aware of how often the data are updated and the continuing availability of the data since in many cases the SOFI analysis will be repeated periodically to track changes over time. Careful attention must be paid to documenting the sources of the data. For example, definitions of the variables and some of the most valuable data sources used in constructing the 2003 SOFI were:

Variable	Definition	Source
Infant Mortality Rate (deaths per 1,000 live births)	Infant mortality rate is the number of infants who die before reaching one year of age, per 1,000 live births in a given year; includes both male and female deaths. (World Bank, World Development Indicators)	US Census Bureau, International Data Base. Mortality Measures (Table 10), 10/10/02 On line at: www.census.gov/ipc/www/idbagg.html
Food availability Cal/cp Low Income Countries	Estimates of per caput food supplies available for human consumption. Calorie supplies are reported in kilocalories. Nationals living abroad during the reference period are excluded, but foreigners living in the country are included. Per caput supply figures represent only the average supply available for the population as a whole and do not necessarily indicate what is actually consumed by individuals. (FAO).	FAO, Foodstat Nutrition Database, July 4, 2002; On line at: http://apps.fao.org/page/collections?subset=nutrition

GDP per capita, (constant 1995 dollars)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant U.S. dollars.	World Development Indicators, on-line 2002. (requires subscription) https://publications.worldbank.org/subscriptions/WDI/
Percentage of Households w/ Access to Safe Water (15 Most Populated Countries)	Access to safe water is the share of the population with reasonable access to an adequate amount of safe water (including treated surface water and untreated but uncontaminated water, such as from springs, sanitary wells, and protected boreholes). In urban areas the source may be a public fountain or standpost located not more than 200 meters away. In rural areas the definition implies that members of the household do not have to spend a disproportionate part of the day fetching water. An adequate amount of water is that needed to satisfy metabolic, hygienic, and domestic requirements, usually about 20 liters of safe water a person per day. The definition of safe water has changed over time. (WHO definition) The countries included are: Bangladesh, Brazil, China, Germany, India, Indonesia, Iran, Japan, Mexico, Nigeria, Pakistan, Philippines, Russia, United States, and Viet Nam.	WHO Basic Health Indicators, http://www3.who.int/whosis/reported/reported.cfm?path=whosis,basic,reported World Development Indicators, on-line 2002. (requires subscription) https://publications.worldbank.org/subscriptions/WDI/ Asian Recovery Data Center, http://www.adb.org/Documents/Books/Key_Indicators/2002/rt03.xls aggregated by the Millennium Project.
Mean Monthly Carbon Dioxide in Atmosphere (ppm)	Atmospheric carbon dioxide determined from the continuous monitoring programs of NOAA, US Department of Commerce.	NOAA Climate Monitoring and Diagnostics Laboratory. US Department of Commerce, July 2002; On line at: http://www.cmdl.noaa.gov/ccg/figures/co2obs.jpg
Annual population additions millions	Mid-year to mid-year differences in world population.	U.S. Bureau of the Census, International Data Base, 10/10/02; On line: http://www.census.gov/ipc/www/idbagg.html

Percent unemployed	The "unemployed" comprise all persons above a specified age who during the reference period were: "without work", "currently available for work", and "seeking work", The unemployment rates are calculated by relating the number of persons in the given group who are unemployed during the reference period to the total of employed and unemployed persons in the group at the same date. (ILO) Recent estimates by MP. The data included only urban areas in China. Data include: Bangladesh, Brazil, China, Germany, Indonesia, India, Japan, Mexico, Philippines, Pakistan, and United States.	International Labor Organization, Laborsta database. 11/30/02 On line: http://laborsta.ilo.org
Literacy rate, adult total (% of people aged 15 and over, world estimate)	Adult Literacy Rate is 100 minus the percentage of people ages 15 and above who cannot, with understanding, read and write a short, simple statement on their everyday life. (WDI)	World Development Indicators, on-line 2002. (requires subscription) https://publications.worldbank.org/subscriptions/WDI/
Annual AIDS deaths (millions)	Annual number of deaths from AIDS-related diseases	Report on the Global HIV/AIDs Epidemic, UNAIDS, December, 2002 http:\\www.UNAIDS.org/worldaidsday/2001/EPIgraphics2001/EPIgraphic1_en.gif
Life Expectancy (World)	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. (World Bank)	US Bureau of Census, International Data Base. Table 010 Updated 10/10/02. On line: http://www.census.gov/ipc/www/idbsprd.html
Number of Armed Conflicts (at least 1000 deaths/yr)	A major armed conflict is defined as the use of armed force between two or more organized armed groups, resulting in the battle-related deaths of at least 1000 people in any single year and in which the incompatibility concerns control of government, territory or communal identity. (Stockholm International Peace Research Institute)	Stockholm International Peace Institute, Yearbook 2002. On line http://editors.sipri.se/pubs/yb02/app01a.html For earlier data see: *Armed Conflict 1946–2000: A New Dataset1* Nils Petter Gleditsch, Peter Wallensteen, Mikael Eriksson, Margareta Sollenberg & Håvard Strand; International Peace Research Institute, Oslo (PRIO) Department of Sociology and Political Science, Norwegian University of Science and Technology (NTNU) & Department of Peace and Conflict Research, Uppsala University http://www.pcr.uu.se/pdf/nilspetterpapper.pdf.

Total External Debt to GNP Ratio: (%) Low and Middle Income Countries	Low- and middle-income economies are those in which 2001 GNI per capita was $9,205 or less. Total external debt is the sum of public, publicly guaranteed, and private nonguaranteed long-term debt, use of IMF credit, and short-term debt. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. (World Bank)	World Development Indicators, on-line 2002. (requires subscription) https://publications.worldbank.org/subscriptions/WDI/ Ratio calculated by MP.
Forest Lands (Million Hectares)	Global estimate of the land area in forest inventories. Includes "total forest," the sum of natural forest and plantations.	Forest Resource Assessment, 2000; provides estimates of forest cover in 1990 and 2000 – and http://www.biodiv.org/gbo/chap-01/chap-01-05.asp#tab1-8
People living on less than $2 per day (Billions, less China)	The poverty reference lines are set at $1 and $2 per day in 1993 Purchasing Power Parity (PPP) terms (where PPPs measure the relative purchasing power of currencies across countries). (World Bank).	World Bank Group, DevNews Media Center, Poverty, Sept., 2002 on line at http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20040961~menuPK:34480~pagePK:36694~piPK:116742~theSitePK:4607,00.html
Terrorist Attacks, number of people killed or wounded	Premeditated, politically motivated violence perpetrated against noncombatant targets by sub-national groups or clandestine agents. The term “international terrorism” means terrorism involving citizens or the territory of more than one country. (U.S. Department of State)	US Department of State, Global Patterns of Terrorism, series of publications, on line at: www.state.gov/s/ct/rls , May 21, 2002. Number of people killed and wounded from 1987- 2001 from State Department; in 1987 from CIA; from 1980-1986 from Center for Defense and International Security Studies

Violent Crime Rate, 17 Countries (per 100,000 population)	Reported total crime rate (murder, rape, robbery, assault), 17 countries, comprising about 4 billion people; the countries included: Argentina, Australia, Bangladesh, Chile, China, France, Germany, India, Italy, Indonesia, Japan, Korea, Malaysia, Philippines, Poland, Russia and the United States.	Basic source of data is: United Nations Surveys on Crime Trends and the Operations of Criminal Justice Systems, 2002, on line at: http://www.odccp.org/odccp/crime_cicp_survey_seventh.html. The US data in this source were corrected by using information from US Department of Justice data: *http://www.ojp.usdoj.gov/bjs/glance/tables/vortrdtab.htm* Recent Australian data was derived from: Australian Bureau of Statistics, http://www.abs.gov.au/Ausstats/abs%40.nsf/e8ae5488b598839cca25682000131612/76c8926bd8a12e1fca2568a9001393f2!OpenDocument and Interpol at http://www.interpol.int/Public/Statistics/ICS/downloadList.asp provided recent data for several countries. National data sources were also consulted. Population data are from: U.S. Bureau of the Census, International Data Base, 10/10/02; On line: http://www.census.gov/ipc/www/idbagg.html When data sources differed, UN Surveys was taken as the standard and used as the basis for interpolation. In addition only years for which data were available in countries totaling more than 1.5 billion were used.
Percent of World Population Living in Countries that are Not Free	Based on a survey and analysis performed by Freedom House and segmenting countries into three categories: free, partly free and not free. Includes consideration of political rights and civil liberties. (Freedom House Survey of Freedom, A Century of Progress)	Adrian Karatnycky, "The 1999-2000 Freedom House Survey of Freedom, A Century of Progress" On line: http://216.119.117.183/ratings US Census Bureau, International Data Base. (Table 10), Nov 15, 2002). On line at: www.census.gov/ipc/www/idbagg.html
Gross Secondary School Enrollment (% school age)	Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers. (WDI)	World Development Indicators, on-line 2002. (requires subscription) https://publications.worldbank.org/subscriptions/WDI/

Percentage of population with access to local health care (15 most populated countries)	The countries included are: Bangladesh, Brazil, China, Germany, India, Indonesia, Iran, Japan, Mexico, Nigeria, Pakistan, Philippines, Russia, United States, Viet Nam.	Basic Health Indicators, WHO, 2000. Aggregated by MP. On line: http://www-nt.who.int/whosis/statistics/reported/reported.cfm?path=statistics,basic,reported&language=english
Number of Agencies Having, Thought to Have, or Seeking Nuclear Capacity	This variable includes countries and groups with or thought to be seeking nuclear weapons capacity.	Primary source: http://www.fas.org/irp/threat/wmd_state.htm ; with additions by MP from http://archive.abcnews.go.com/sections/us/terrorism_groups/

Task 3, Forecasting the Data, will result in10-year forecasts of each variable. The simplest approach is to use time series methods; in the MP, the following equations were used in the fitting process[2]:

1. Linear	$v = m*t + b$
2. Exponential	$\ln(v) = m*t + b$
3. Power function	$\ln(v) = m*\ln(t) + b$
4. Logarithmic	$v = m*\ln(t) + b$
5. Inverse v	$1/v = m*t + b$
6. Inverse t	$v = m/t + b$
7. S Shaped	$\ln\{(v/L)/[1-(v/L)]\} = m*t + b$

where v is the value of the variable, L is the variable's upper limit when one can be discerned, m is the slope of the fitted curve, and b is the intercept at t=0

This approach, while simple, assumes, implicitly, that historical trends will continue unabated into the future. In the Project's 2002 and 2003 work, a special effort was made to depart from this extrapolative approach by introducing future unprecedented developments into the forecasts using Trend Impact Analysis (TIA) (described in detail elsewhere in this volume). The events included in a TIA can come from many different sources including scenarios, or separate questionnaires.

Task 4. Analysis, involves the computation of the index and the study of its behavior. Suppose a composite indicator were to include time series measures of population additions (number of people) and economic vitality (GDP per capita). Clearly the numbers representing these two variables could not simply be added; it would be necessary first to express their values in the same dimensions or in non-dimensional form. Making them non-dimensional is called "normalizing." The normalizing method used in the MP analysis, assigned a value of 100 to the

[2] The statistical package used in the analyses is Statplan 5.0, developed by The Futures Group.

most normative estimate and a value of zero to the dystopic estimate, neither of which may have yet occurred. This is the reason why respondents are asked for best and worst estimates and weights in the questionnaire.

In this approach, one is forced to confront the questions: just how good or bad could things be? These would be the standards used in the following equation:

Eq 1 p(n,t) = (Vn (t) - dystopic value of Vn) *100/(normative value of Vn - dystopic value of Vn)

where p(n,t) is the normalized value for the variable n at time t, that is the percentage of the range between the highest and lowest values of Vn, and where Vn (t) is the value of variable n at time t.

Consider this simple example in which the normative and dystopic values and their weights come from the responses to a questionnaire

Variable	Normative Value	Normative Weight	Dystopic Value	Dystopic Weight
Population additions	63.4	6.38	84.0	7.33
GDP/Cap	8290	7.03	4437	8.03

Suppose the forecasted value for population additions five years hence was 72.752 and for GDP/cap was 5991. Then, using the equation above, the normalized values for these variables would be:

Population additions= (72.752-84.0)*100/(63.4-84.0)= 54.62%
GDP/Cap =(5991-4437)*100/(8290-4437) = 40.33%

After the indicators have been scaled as discussed above, they must be combined. In any index, not all of the indicators are equally important. Therefore it is appropriate to combine them as a weighted sum. The weights can be estimated by individuals or groups, or given appropriate historical data, through regression. If the form of the index is:

Eq 2 Index (t) = W1*p(1,t) +W2*p2 (2, t) +W3*p(3, t)

where the W values are the weights and the p(n, t) are the normalized values of the variables. All indexes of which we are aware have assumed that weights are constant and independent of the value of the variable they modulate (and in most instances add to unity). We believe that in the real world, the weights assigned to some indicators should change as the values of the indicators rise and fall. When, for example, an indicator reaches a level of satiation, it is no longer as important as it used to be. As pointed out earlier, food intake can serve as an example. When calories per person is below 1500 calories, the variable is very important. When it is above 3,000, the sense of urgency associated with hunger no longer gives this variable much weight.

For this reason we express the relationship between the variable and its weight as an S- shaped curve[3].

Eq 3 $$W(n, p) = WB + \frac{(WW-WB) * e^{K1}}{(1 + e^{K1})}$$

where:

W(n, p) is the weight of a variable n at p percentage of its range

WW is the weight assigned to the dystopic (worst) value of the variable

WB is the weight assigned to the normative (best) value of the variable

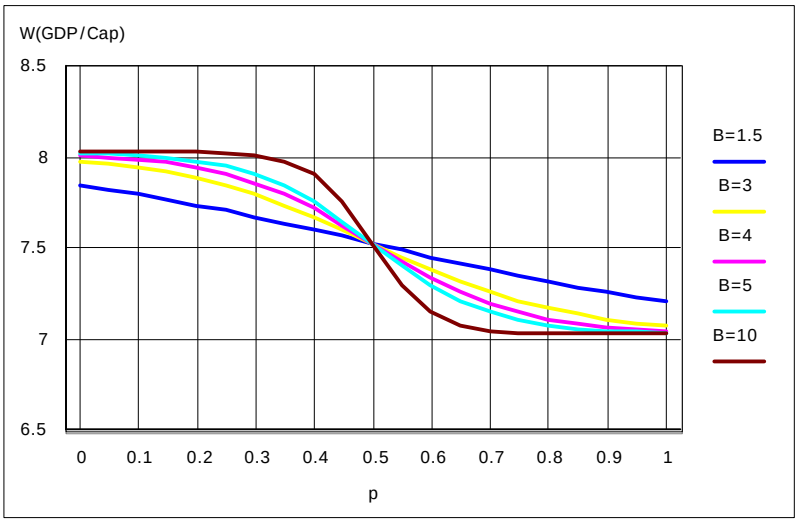
K1 is (A * p + B); and A and B are constants that determine the slope of the S- shaped curve at the inflection point.

If we want a symmetrical curve then when p= 0.5, W(n, p)= (WW+WB)/2

Substituting:

B = -.5 A

This allows the whole family of S- shaped curves to be determined by a single constant. The family of curves for our example appears as follows:



The analyst selects the value of the constant which best describes the relationship between the variable and its weight; in the case of the two variable illustrated this might be B=4.

[3] *S- SHAPED FUNCTIONS ARE WIDELY USED IN DEPICTING THE GROWTH OF CLOSED POPULATIONS, TECHNOLOGICAL PROGRESS, NEURAL NETWORKS, MARKET PROJECTIONS, AND ELSEWHERE.*

Using this function to combine the variables will produce a forecast of the SOFI, a range of uncertainty, an explanation of the reasons for changes in slope and dips and peaks, and a test of the sensitivity of the curve to certain of the future policies and developments.

The SOFI can be calculated using:

Eq 4 $$SOFI = \frac{SUM\ (p(n, t) * (W(n, p))}{SUM\ (p(n, T) * (W(n, p))}$$

Where T is the reference year for the SOFI.

Although the research is not complete, use of the S- shape function may sometimes produce counter intuitive results. For example, if one were to produce a SOFI forecast of variables balanced between those improving and those worsening, and further improvement were to occur in one of the desirable variables while all of the others stayed as they were, then the weight of the desirable variable would decrease and despite the gain in a desired measure, the SOFI might decrease. Why? Because that variable which used to be a worry and therefore more heavily weighted has become relatively less important.

V. Strengths and Weaknesses of the Method

There are some dangers in such an index. The future cannot be reduced to a single number. An index of this sort can mask variations, for better or worse, among regions, nations, or groups. The apparent precision of an index can easily be mistaken for accuracy. For these reasons, many people interested in tracking social or economic conditions prefer to keep separate and distinct the variables that they consider important. Nevertheless, the promise of a *State of the Future Index* is alluring: it offers the hope of identifying positive and negative changes and points of leverage for policy, as well as achieving some measure of balance in answering questions about the outlook for the future.

A SOFI can be computed for individual countries or groups and used to compare their apparent future outlook to each other as well as to the world as a whole. This application requires the use of country rather than global data, and the use of weights that are appropriate to the country or region. Thus it is quite conceivable that two political groups in a single country, working with the same data set, could produce quite different SOFI's by weighting the variables according to their views of the importance of the variables and by their views of the best and worst outlook for each variable. Political differences can be quantified in this way.

VI. Frontiers of the Method

There are many factors that could cause the projected SOFI to be different than the projections produced by the method outlined above. Unexpected events may occur that will change the extrapolations of the variables. Including such developments in the forecasts of the variables is

the focus of other forecasting techniques, but are mentioned here because their use would enrich a SOFI analysis. The Millennium Project's 2002 and 2003 work with SOFI utilized Trend Impact Analysis. For example, a few of the events that could cause great differences in one variable are listed below (these developments were suggested or are based on responses from previous Millennium Project Lookout Panels and are only an illustration of what is certainly a much longer list. It was used as part of a TIA analysis in the 2003 SOFI):

Calories per Capita	Mono-culture agriculture proves susceptible to attack by adapted organisms. Biotech in agriculture: improved food availability as well as enhanced animal health, insect-and disease resistant plants, etc. Water: many political water issues resolved (e.g. 50% of current disputes) Inexpensive very long term contraceptives: wide availability and low cost Sustainability: environmental consciousness is pervasive, affects decision making everywhere. Convergence of information/ communication technologies (Including Internet) lead to improved education, employment, environment, health, and production. Mideast war escalates, Iraq war and its consequences interminable, or Chinese- Taiwan wars, accounting for more than 50,000 casualties over 4 years Large families gain favor in most developed countries, raising over all annual population additions 5%. International corporations help build national infrastructures and services to promote the development of poor countries Genetic design: essentially full control of genetics and biochemical processes of all living organisms. Global economic depression resulting in drop of GDP per capita by 15%. Desalination: cost effective desalination eventually increasing safe water access by 20%. Further industrialization of China, India. Great increase in economic participation of women in most poor countries (e.g. through micro-entrepreneurship), increasing GNP/cap 2% worldwide

Trend Impact Analysis produces a range of outcomes rather than just a single value. It begins with an extrapolation of a time series. This is taken to be a "baseline forecast"; that is the future of the variable if there were no future trend-changing developments of the sort listed above. Next a list of such developments is constructed, using the analysts' imagination, literature search, Delphi, or any other technique. These developments might include unique technology, societal changes, political actions or any other change that may affect the future course of the variable. Each development on the list is expressed in terms of its expected probability of occurrence over the future time interval of concern, and, were it to occur, its impact on the variable under study.

Given such a list, TIA "plays out" all possible combinations of the events and their effect on the variable (Monte Carlo), adjusting the baseline forecast in the process. In this simulation, a single run consists of deciding, at each point in the forecasted time range, whether or not each event "occurs" and adjusting the baseline forecast accordingly. Ideally, more than 1,000 runs of this sort are made, playing out the various combinations of events and their impacts. The result of each simulation is essentially a mini- scenario. These are combined statistically to find the median and quartiles, and the TIA results are generally presented as a "fan" of outcomes, spread according to their probability.

Although it may present a more realistic view of the future, even this technique involves great over-simplification. For example, it omits any interaction among the future events (the occurrence of one may well affect the probability of other events); the list of future events will certainly omit some that in retrospect will be seen as having been important; the variable is taken to exist in isolation but in reality will be affected by other variables. Nevertheless, it would be attractive in this application and should SOFI tracking be initiated, TIA or another similar method that accepts perceptions about future perturbing events should be included. Trend Impact Analysis was used in the Millennium Project's 2002 and 2003 SOFI work that can serve as a reference for this technique in a SOFI application.

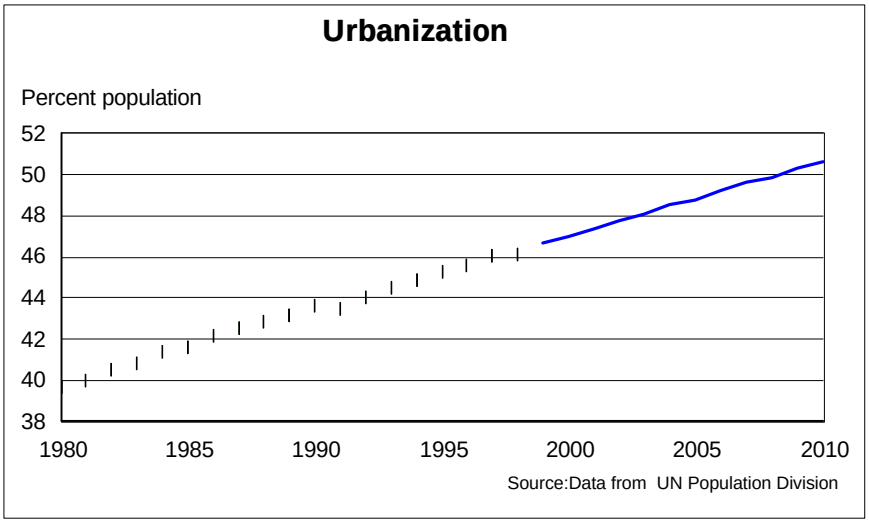
Another means for improving the forecasts of the variables would be to include a cross impact analysis. In the example of this paper, the variables were considered to be independent, but in the real world when one variable changes, others may be affected. A full consideration of the SOFI would include such complexities.

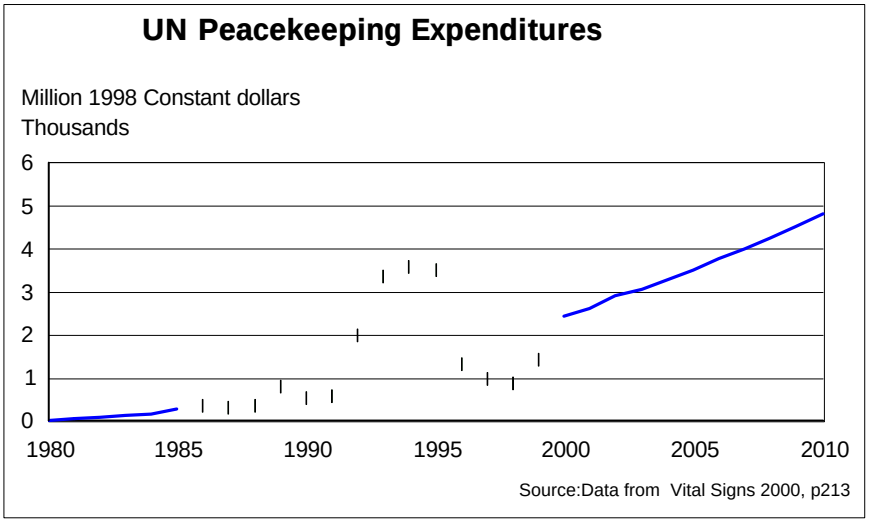
It is suggested that in any systematic use the SOFI be re-evaluated and computed annually and published, together with a narrative and accompanying charts of the key variables that explain reasons why the future appears to be better or worse than before.

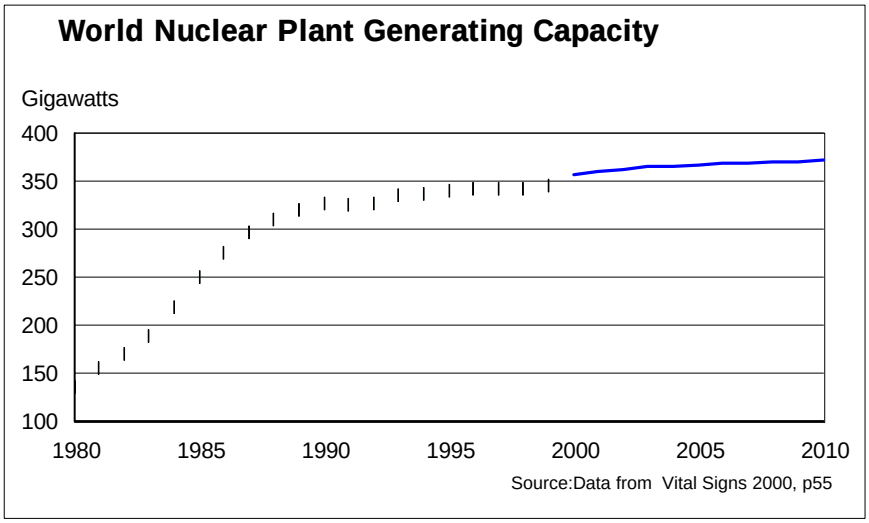
A new kind of "dashboard" software that integrates databases and graphics should be considered. It would show changes in the variables much like the dashboard of a car shows changes in speed, temperature, fuel, etc. to help the driver make decisions. SOFI could be the central gauge with key indicators around it, while other indicators that don't quite fit but that are important could be in the other displays or gauges.

An attempt should be made to derive the weights statistically by correlating public opinion about the future, or some objective measures, with the set of indicators designated for the SOFI.

Several variables were identified that are apparently important but were not included in the SOFI because it was not clear whether increases in value are, on the whole, good or bad. Some work needs to be done to determine how such variables can be accounted for.


Urbanization
Percent population
52
50
48
46
44
42
40
38
1980
1985
1990
1995
2000
2005
2010
Source:Data from UN Population Division


UN Peacekeeping Expenditures
Million 1998 Constant dollars
Thousands
6
5
4
3
2
1
0
1980
1985
1990
1995
2000
2005
2010
Source:Data from Vital Signs 2000, p213


World Nuclear Plant Generating Capacity
Gigawatts
400
350
300
250
200
150
100
1980
1985
1990
1995
2000
2005
2010
Source:Data from Vital Signs 2000, p55

In the future, some means should be found to accommodate such variables.

While the work thus far has dealt with a global SOFI, it is possible and important to construct similar indexes for countries, regions, or cities. If the parameters selected for the future index for these areas are the same as those used for a global measure, then direct comparisons could be made. For example, are things improving for our region as much as for the world as a whole? What set of improvements would change our outlook to be more in line with global prospects?

Most importantly, we believe that a unified program (rather than the Lotus macros that were used in our work) should be written. Ideally, such a program would permit individuals and agencies to enter data for variables that depict their particular situations, draw from existing or proprietary data bases, and construct and track their own SOFI's. This will simplify the problem of following SOFI's over time, comparing countries or organizations cross sectionally, and testing policies in the simplest possible way. In fact, the Millennium Project's Silicon Valley Node has begun to develop such software.

VII. EXAMPLE OF THE METHOD

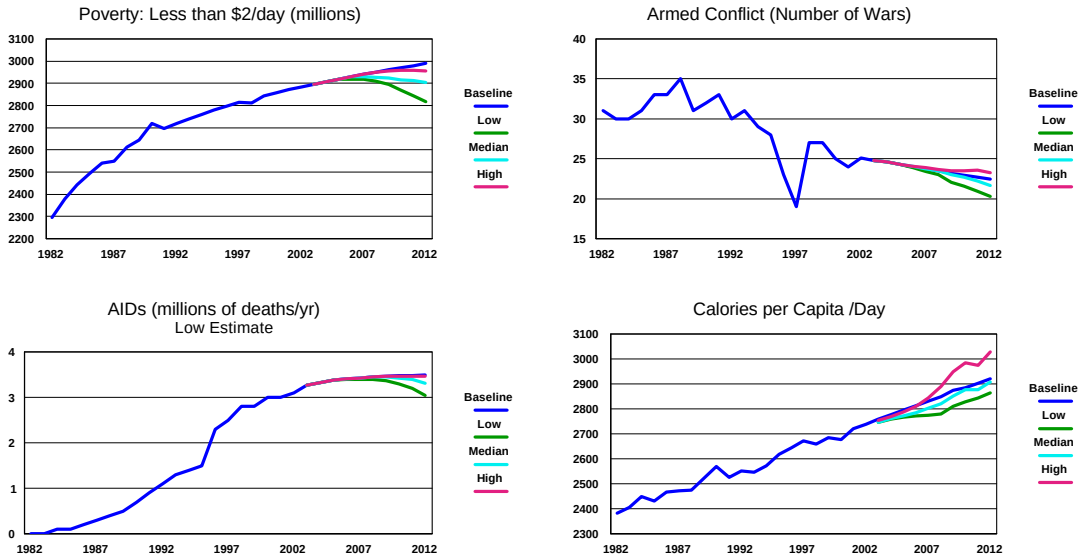
As noted earlier, two applications have been made to date and a third is in preparation. In the most recent application, to be published in 2003, the variables included:

Infant Mortality Rate (deaths per 1,000 live births)
Food availability Cal/cp Developing Countries
GNP per capita PPP (constant 1995 $US)
Percentage of Households w/ Access to Safe Water (15 Most Populated Countries)
CO2 atmospheric, ppm
Annual population additions millions
Percent unemployed
Literacy rate, adult total (% of people aged 15 and above)
Annual AIDS deaths (millions)
Life Expectancy (World)
Number of Armed Conflicts (at least 1000 deaths/yr)
Debt/GNP; Developing Countries (%)
Forest Lands (Million Hectares)
Number of People Living on Less than $2 per day
Terrorist Attacks
Violent Crime, 17 Countries (per 100,000 population)
Percent of World Population Living in Countries that are Not Free
School Enrollment, secondary (% school age)
Percentage of population w access to local health care (15 most populated countries)

After developing the SOFI a second, more pessimistic, scenario was developed, based on current conditions in the world. In this add-on, a 20th variable was added to depict nuclear proliferation: *Number of Countries Having or Thought to Have Nuclear Capacity.* This scenario also involved an assumption about a continuing increase in the number of AIDs deaths and the threat of weapons of mass destruction (WMD) falling into the hands of terrorists as a TIA event.

TIA was used to forecast the variables and four examples are shown below:

TIA Forecasts of Variables

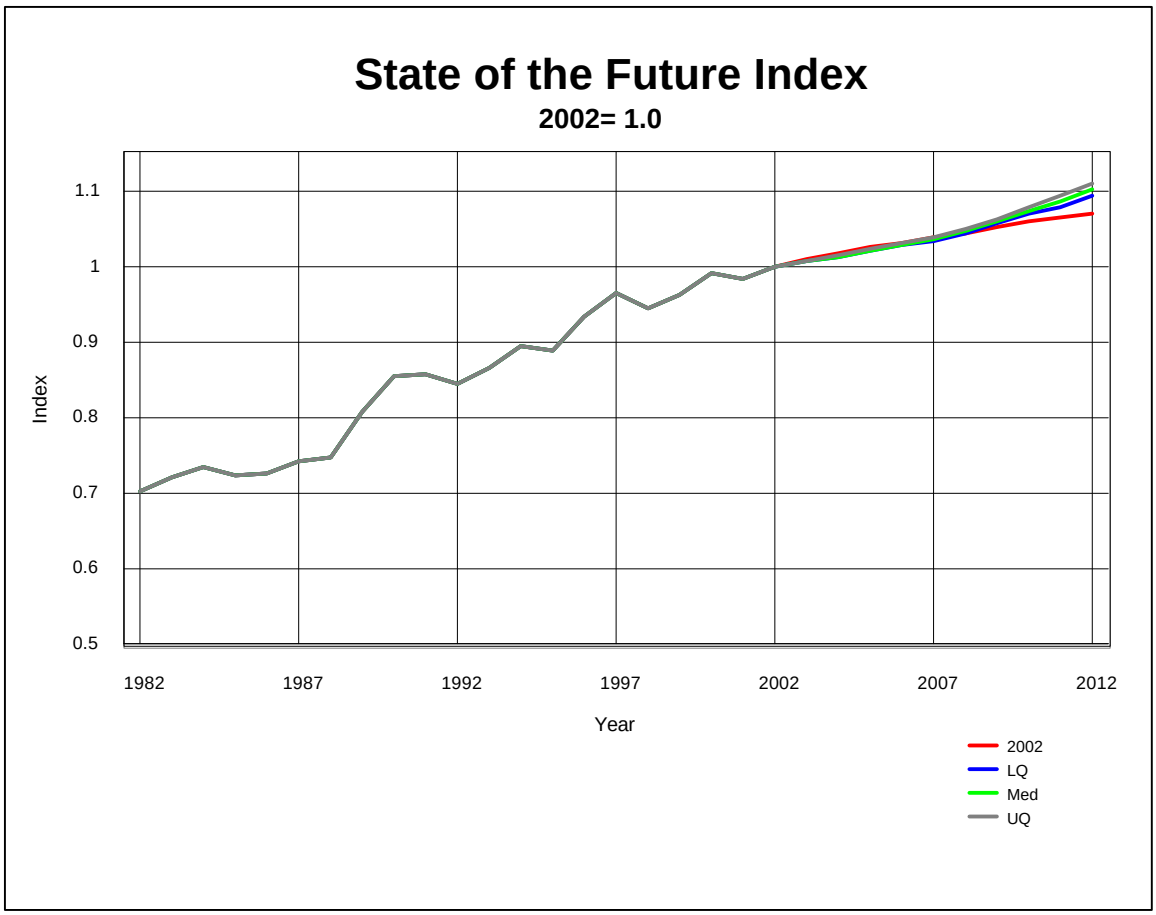


The table below summarizes the forecasts used in the 2003 Millennium Project SOFI:

Variable	Curve Type	R^2	No Points	Value Best	Value Worst	Weight Best	Weight Worst
Infant Mortality Rate (deaths per 1,000 live births)	Inverse v	.980	33	29	81	5.42	7.70
Food availability Cal/cp Developing Countries	Linear	.960	21	3200	2000	5.50	8.39
GNP per capita PPP (constant 1995 $US)	Linear	.977	22	8290	4437	7.03	8.03
Percentage of Households w/ Access to Safe Water (15 Most Populated Countries)	S- Shaped	.533	7	100	59	6.05	8.52
CO2 atmospheric, ppm	Exponential	1.00	23	340	410	5.78	7.68

Annual population additions millions	Inverse V	.649	33	63	84	6.38	7.33
Percent unemployed	Linear	.779	22	6	14	5.15	7.56
Literacy rate, adult total (% of people aged 15 and above)	Linear	.996	22	89	60	5.21	6.74
Annual AIDS deaths (millions)	S- Shaped	.987	23	3	23	5.61	7.24
Life Expectancy (World)	Power Function	.878	33	74	56	5.38	6.21
Number of Armed Conflicts (at least 1000 deaths/yr)	Exponential	.269	22	14	51	6.30	7.83
Debt/GNP; Developing Countries (%)	Power Function	.923	21	25	50	5.66	7.17
Forest Lands (Million Hectares)	Log Curve	.911	6	4522	2948	6.69	7.70
Number of People Living on Less than $2 per day	Log Curve	.903	3	1000	3000	6.24	7.65
Terrorist Attacks	S- Shaped	.348	21	1000	25000	5.90	7.09
Violent Crime, 17 Countries (per 100,000 population)	S- Shaped	.317	17	1918	4057	6.00	7.50
Percent of World Population Living in Countries that are Not Free	Linear	.375	22	20	44	6.22	7.33
School Enrollment, secondary (% school age)	S- Shaped	.929	11	86	56	6.13	7.44
Percentage of population with access to local health care (15 most populated countries)	S- Shaped	.604	5	96	71	5.40	6.91
Nuclear Proliferation	Exponential	.348	24	0	100	3.00	4.00

As noted earlier, these computations resulted in the SOFI curve as follows:



Why did the SOFI grow from 1980 to 2000?

Simply because many of the variables included in the SOFI improved, for example some of the most important favorable changes occurred for the following variables:

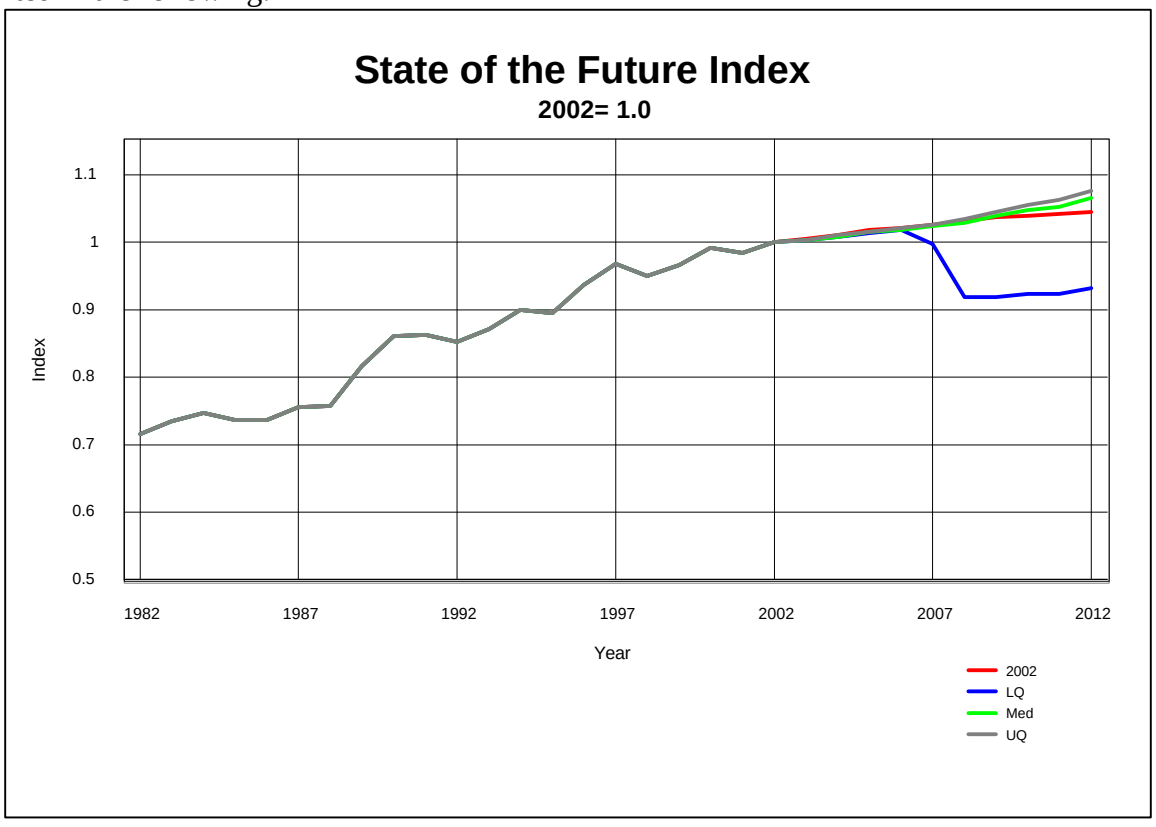
- GDP per capita grew
- Calories per capita increased
- Life expectancy grew
- Terrorist Attacks diminished
- Literacy grew
- Infant Mortality dropped
- Access to Fresh Water improved
- Access to Health Care improved
- School Enrollment Increased

But some variables moved in unfavorable directions:

- Industrial CO_2 emissions grew
- Unemployment moved in a generally unfavorable direction
- Forest Lands decreased
- Rich Poor Gap got wider
- AIDS Deaths grew
- Developing Country Debt increased

With the weights that were assigned and the levels of changes experienced against the background of best possible and worst possible scenarios, on balance the favorable changes outweighed the unfavorable in the index.

In the 2003 SOFI work, introducing factors associated with a pessimistic scenario produced a different outlook. The changes made included: a much more pessimistic forecast for AIDs deaths, the introduction of a 20th variable: Nuclear Proliferation, and a new TIA event "weapons of mass destruction (WMD) falling into the hands of terrorists." Taken together these changes resulted in the following:



This example illustrates how SOFI can be used to explore the causes for uncertainty, the uncertainty range, and how various events and policies may affect the future.

APPENDIX: STATE OF THE FUTURE INDEX (SOFI) QUESTIONNAIRE

Note: The questionnaire presented in this section includes a set of variables that is more extensive then that ultimately used in constructing the SOFI. The deletions occurred as a result of removal of redundancies, lack of available data, or low importance.

The Millennium Project

State of the Future Index (SOFI) Questionnaire

(Used in the 2001 Study)

Section 1

Remember, you are not requested to answer every question. Just provide your judgments about those items within your expertise and interest.

		1	2	3	4	5	6
	Indicator	Norm or Best Plausible by 2011	Dystopic or Worst Plausible by 2011	Average Values 1980-00	Weight of Norm in 2011	Dystopic Weight in 2011	Source
1	Infant Mortality Rate (deaths per 1,000 live births)	25	90	71			U.S. Bureau of the Census, International Data Base, 2000
2	Food availability Cal/cp Low Income Countries	3,200	2,000	2,238			FAO, Foodstat Nutrition Database, 2001; http://apps.fao.org/page/collections?subset=nutrition
3	GNP per capita (constant 1995 $US)	6,300	4,400	4,830			World Bank, International Comparison Program database, 2000
4	Percentage of House-holds with Access to Safe Water	90	70	72			WHO Basic Health Indicators, Asia Recovery Data Information Center aric.adb.org/indicators; and WRI Environmental Health Indicators, 2000; aggregated by the Millennium Project
5	Average annual global temperature (Centigrade)	14	16	14			Goddard Institute for Space Studies, March, 2001; http://www.giss.nasa.gov/data/update/gistemp/graphs/
6	CO2 emissions, industrial (mil kt)	14	40	19			Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, 2000

		1	2	3	4	5	6
	Indicator	Norm or Best Plausible by 2011	Dystopic or Worst Plausible by 2011	Average Values 1980-00	Weight of Norm in 2011	Dystopic Weight in 2011	Source
7	Annual population additions millions	65	85	81			US Bureau of Census International Data Base, 1999.
8	Contraceptive prevalence (% of women aged 15-49)	65	30	45			Surveys (such as Demographic and Health Survey or Living Standards Measurement Study) from national sources; WDI CD ROM, 2000
9	Percent unemployed	5	12	7			ILO data for unemployment used as a basis for global aggregation, about 80 countries; www.laborsta.ilo.org
10	Literacy rate, adult total (% of people aged 15 and above)	90	60	70			UNESCO Statistical Yearbook, 1999
11	Literacy rate, adult female (% of females aged 15 and above)	90	50	62			UNESCO Statistical Yearbook, 1999
12	Immunization DPT (percent babies under 12 months)	98	40	69			World Health Organization, 2000
13	Annual new HIV cases (millions)	1	10	2.8			UNAIDS and CDC www.unaids.org
14	Annual AIDS deaths (millions)	0.5	20	1			UNAIDS, March, 2001; www.unaids.org
15	Life Expectancy (World)	75	60	60			UN, World Population Prospects: The 1998 revision, NY: December 1998)
16	Women in Parliaments (% of total)	25	12	12			International Parliamentary Union, "Women in Parliaments 1945-1995" and 2000 data
17	Refugees and others of concern to UNHCR (millions)	6	75	16			United Nations High Commissioner for Refugees, (UNHCR) various data series. <www.unhcr.org
18	Telephone Lines/ Cap	500	100	106			ITU, World Telecommunication Database
19	GDP per unit of energy use (1995 US$ per kg of oil equivalent) (High Income Countries)	8	4	5			EIA International Energy Outlook 2000 (includes projection) Read from graphs and interpolated

		1	2	3	4	5	6
	Indicator	Norm or Best Plausible by 2011	Dystopic or Worst Plausible by 2011	Average Values 1980-00	Weight of Norm in 2011	Dystopic Weight in 2011	Source
20	R&D expenditures (Developed Countries, billions 1992 US$)	700	170	309			Science and Engineering Indicators, 2000, National Science Foundation
21	Private consumption per capita (constant 1995 US$)	5,500	2,500	2,972			World Bank national accounts data, and OECD National Accounts data, WDI, 2000
22	World Grain Production	2,300	1,400	1,691			Worldwatch, Vital Signs, 2000, based on USDA data.
23	Number of Armed Conflicts (at least 1000 deaths/yr)	10	50	28			Stockholm Institute for Peace Research, 2001
24	Developing Countries Debt (billion 1998 dollars)	1100	5,000	1,836			World Bank, Global Development Finance, 1999
25	Forest Lands (Million Hectares)	4,500	3,000	3,993			FAO <www.fao.org
26	Rich Poor Gap (Ratio of global average income of top 5% to bottom 5%)	6	300	96			World Bank, Data on Poverty, 2000
27	Terrorist Attacks	200	700	456			"Patterns of Global Terrorism", US Department of State, Publication 10687, 1999
28	Violent Crime (per 100,000 population)	2,800	4,000	1,178			"UN Survey on Crime Trends and Operation of the Criminal Justice System, 2000;" uncijn.org/Statistics/ statistics.html; in countries totaling about 4 billion people
29	Internet Host Computers (millions)	200	50	10			Internet Software Consortium, 2000
30	Percent of World Population Living in Countries that are Not Free	20	45	39			Adrian Karatnycky, "The 1999-2000 Freedom House Survey of Freedom, A Century of Progress"
31	Number of International NGO's	35,000	20,000	17,833			Union of International Organizations and Worldwatch, 2000
32	Opium Production Worldwide (Metric Tons)	1,000	5,500	2,995			US State Department, International Narcotics Control Strategy Report, Mar. 2000

		1	2	3	4	5	6
	Indicator	Norm or Best Plausible by 2011	Dystopic or Worst Plausible by 2011	Average Values 1980-00	Weight of Norm in 2011	Dystopic Weight in 2011	Source
33	Scientific and Technical Articles Published (Thousands)	750	500	479			National Science Foundation, Science Indicators, 2000
34	Oil Resources, Production, Identified and Estimated Undis-covered (BBO)	5,000	2,000	2,118			US Geological Survey World Petroleum Assessment, 2000
35	Female Employment Ratio	70	50	53			Comparative Civilian Labor Statistics- Ten Countries, US BLS, December, 2000
36	Patents Granted, Worldwide	300,000	75,000	93,275			US Patent and Trademark Office, 2000
37	Number of ISO 14000 certifications	600,000	20,000	7,339			International Organization for Standardization, 2000, <www.iso.ch
38	School Enrollment, secondary (% school age)	85	55	63			World Development Indicators, 2000 WINSTARS CD Rom
39	Percentage of population with access to local health care (15 most populated countries)	100	75	86			Basic Health Indicators, WHO, 2000 http://www-nt.who.int/whosis/statistics/basic_whr/basic_whr.cfm?path=statistics.basic.basic_whr&language=english
40	Number of Nuclear Warheads	10,000	50,000	52,598			Global Nuclear Stockpiles 1945-1997", Bulletin of Atomic Scientists: www.bullatomsci.org/issues/nukenotes/nd97nukenote.html; and Coalition to Reduce Nuclear Arms, www.clw.org/coalition/nukelev.htm, 2000; projection per Start II
41	Microprocessor Clock Speed (MHz)[4]	10,000	1,000	150			Intel Corporation http://www.intel.com/intel/intelis/museum/exhibit/hist_micro/hof/hof_main.ht
42	Satellite Launches	150	50	124			Data from 1980 to 1998 compiled by Worldwatch; 1999 data from: stargate.1usa.com/stamps/launches/laun1999.htm

[4] If this work were repeated today, higher estimates would probably be used.

		1	2	3	4	5	6
	Indicator	Norm or Best Plausible by 2011	Dystopic or Worst Plausible by 2011	Average Values 1980-00	Weight of Norm in 2011	Dystopic Weight in 2011	Source
43	Number of Companies using ISO 9000	900,000	300,000	85,223			International Organization for Standardization, 2000, www.iso.ch

Section 2

Please add suggestions for other indicators that, in your judgment, are at the importance level of 8 or above (in either the best or worst plausible worlds) and that you believe should be added to the State of the Future Index.

Indicator	Norm or Best Plausible by 2010	Dystopic or Worst Plausible by 2010	Average Values 1980-00	Weight if Norm were Achieved	Weight if dystopic were Achieved	Source

Section 3

If you were restricted to only 5 variables, which would you include? (Please just write the number of the variable in the blank space)

1. _____
2. _____
3. _____
4. _____
5. _____