Real Time Delphi Study of Four Economic Variables

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Executive Summary

This report describes a study conducted for The Society of Actuaries (SOA) and the Canadian Institute of Actuaries (CIA) designed to acquaint actuaries and other financial professionals with the application of methods of futures research that could supplement traditional actuarial forecasting practices and to obtain insights into the rationales and thought processes experts use in making assumptions about the long-range values of economic variables.

This work followed a similar study that the SOA performed in 2005 but used more advanced futures research methods. As was the case in the 2005 study, the purpose of the current study was to demonstrate these techniques through a realistic application, rather than prediction, especially given the small (intended) number of participants

Substantively, the study that ran from late August 2018 until March 2020 focused on two-, five- and 10-year forecasts for four U.S. economic variables

1. Annual increase in the Consumer Price Index (CPI)
2. 10-year Treasury spot yields
3. S&P 500 total rate of return
4. Corporate Baa spot yields

Small expert groups comprised of about 30 actuaries and futurists provided judgments about these variables in two surveys, the first of which ran during July 2019 and asked for direct estimates of the future values of the variables. The second, which ran from November 2019 to January 2020, explored the consequences of possible future developments on the course of the variables. Because this study was designed to demonstrate several futures techniques, the time period taken to perform these surveys was longer than most other users of the techniques have experienced.

The respondents provided judgments about the future values of the variables and ranges of expectations, as well as values that might be considered catastrophic and timing of regression to the mean. In addition, they were quite generous in sharing their rationales; more than 300 reasons were given. They nominated over 90 future developments (later consolidated down to 28) that they felt were important to the future course of the variables and estimated the probabilities and possible impacts of these developments.

Although the study was completed a few weeks before the COVID-19 pandemic became a major global issue, the panel identified several developments that were soon to capture the word's attention; these were hypothetical at the time of the study: "Pandemic kills 1% of world population (Spanish flu of 1918 is estimated to have killed between 50 million and 100 million people worldwide)" and "Price of oil drops

below $30 for more than a year." The panel judged that the probabilities of each of these developments was quite low (less than 15%), nevertheless their inclusion was remarkable.

Principal conclusions included:

- This work illustrated several systematic techniques for forecasting the future value of time series variables by collecting estimates of individuals in a group; by combining extrapolative forecasts obtained through use of historical data and statistical curve fit methods; and through combining group judgments about future developments that could deflect the extrapolations.

- The curve fitting methods that were used are well known and are based on regression to minimize errors when curves of known shapes are fit to the data. The method for eliciting expert judgments about future developments and their consequences was Real Time Delphi. The method for combining the expert judgments about probability and impacts of future developments with extrapolations was Trend Impact Analysis. A Monte Carlo model was used in which random numbers determined the assumed occurrence or nonoccurrence of future developments based on their estimated probabilities; this model was used to create a large number of mini-quantitative scenarios that led to definition of expected median and interquartile ranges of the variables under study. The computer algorithms developed for this study are available for SOA/CIA member use.

- The study also demonstrated how the methods could be used in policy analysis by simulating policy decisions through changing probabilities or impacts and observing the effects on the variables of interest.

Many of the reasons participants provided were eloquent statements of hope and uncertainty about the future. The range of expectations was quite wide, perhaps wider than at any time in the recent past. From an economic point of view, the forecasts generally reflected an inflationary future, largely determined by uncertain politics, man-made and natural disasters, and chance.

Section 1: Introduction and Background

The SOA and the CIA have performed a forecast of four economic variables to acquaint actuaries and other financial professionals with methods for forecasting and analysis that can be used in situations of high uncertainty. The specific forecasts are less important than the demonstration of techniques, although the study was successful in both respects.

The study performed was a two-step forecast of the future values of four economic variables. The principal purposes of this study were to 1) acquaint actuaries and other financial professionals with several methods of futures research that may supplement traditional forecasting practices and 2) to obtain insights into the rationales and thought processes experts use in making assumptions about the long-range values of economic variables. This work followed a similar study that the SOA performed in 2005.

The four variables on which this study focused were:

1. Annual increase in the CPI
2. 10-Year Treasury spot yields
3. S&P 500 Total rate of return
4. Corporate Baa spot yields

One of the major objectives of this work was to introduce and demonstrate the following two futures techniques: 1) Real Time Delphi (RTD), a systematic means of collecting opinions from a group of experts, and 2) Trend Impact Analysis (TIA), a system for modifying extrapolations to include perceptions about unprecedented developments.

They were supplemented by the following two techniques already familiar to actuaries: 1) curve fitting, a technique for extrapolating historical data into future years, and 2) Monte Carlo modeling, a statistical technique for introducing randomness into otherwise deterministic forecasts.

All four techniques are described in Section 2, where references for further study can be found.

The first step in this study, named RTD1, was designed to obtain direct estimates of the future values of the variables and to learn about the thought processes behind the forecasts. It was performed between July 8 and July 31, 2019, and collected judgments from a small group of experts (about 30), principally actuaries and futurists. The experts were asked for their high, most likely and low estimates of the value of the four variables at three future time periods (two, five and 10 years hence) and to provide the rationales for their answers. Section 2.1.1 explains the RTD process more thoroughly; Section 7 provides examples of some of the insightful qualitative rationales, and all rationales are presented verbatim in Appendix C. The study also produced a listing of future-shaping developments that respondents provided; these were quite useful in the TIA portion of the study.

The second step in this study, named RTD2, ran between Nov. 11, 2019, and Jan. 31, 2020, and asked respondents for their judgments about future external developments—economic, political, technological or social—that could swing extrapolative forecasts based on fitting curves to historical data or to the direct forecasts produced in RTD1. The curve fitting results are presented in Section 4 and the TIA results in Section 5.

An initial list of developments was derived from comments furnished by the respondents in the course of explaining the rationales behind their answers in RTD1. This list was further refined by the project oversight group (POG) through combining and clarifying items to produce an initial list of 28 external developments thought to have potentially significant consequences for the future course of the four variables (see Section 5.) RTD2 produced group judgments about the probabilities of these 28 future developments and their potential impacts on the four variables. These judgments were used in a TIA to produce new forecasts of the four economic variables, not only in light of their histories but considering the external developments and the power of those developments to determine the course of the variables. The TIA method is designed to modify a surprise-free forecast, usually an extrapolation of a time series, for example, to systematically account for unique developments of the future. The future is rarely surprise free, so TIA is a method of amending a time series extrapolation to include the envisioned effects of a set of future developments.

Probabilistic forecasts of the four variables have been produced in this study using an Excel macro Monte Carlo program; this process integrated perceptions about the 28 selected future developments derived from RTD1 and evaluated in RTD2. Figure 1 illustrates the study flow; the remainder of this report presents further details about the process and results.

Figure 1
STUDY FLOW
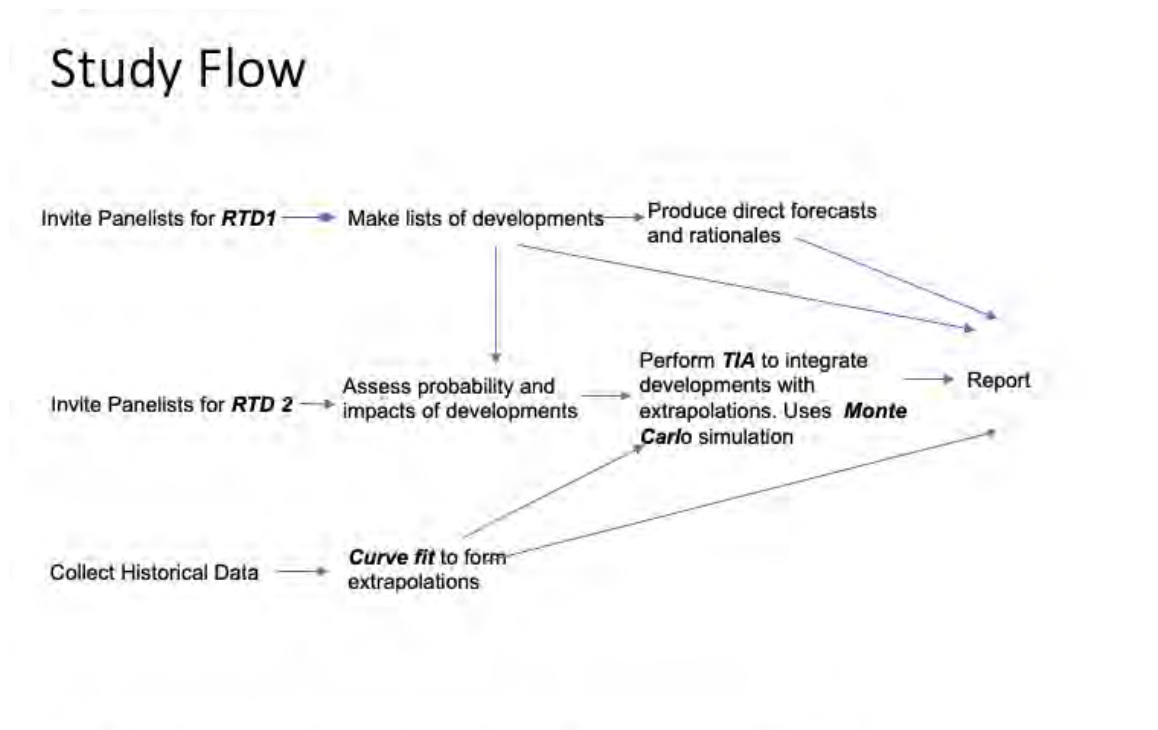
Note: Entries in bold italics represent techniques used and demonstrated in this work.

Section 2: Brief Descriptions and Methodologies

This section sketches some of the important features of the four methods employed in this study. Further detail can be found in Appendix D and references for further reading are provided there.

2.1 FUTURES RESEARCH TECHNIQUES

2.1.1 REAL TIME DELPHI

Beginning in the 1960s, Delphi studies were used to collect expert judgment from small groups of experts using sequential questionnaires, each building on the results of the prior questionnaire. The questioning sequence was designed to elicit reasons for outlier positions, which when fed back to the group tended to move the group average toward stability of results or consensus. The essential elements of a Delphi study are the need for expert participants, since panel sizes are generally small; anonymity of participants to avoid some biases; and feedback of group opinion. Despite their popularity, Delphi studies have been expensive and take months to complete: a three-round Delphi can take three to four months. Real Time Delphi, by contrast, is an efficient online system that does not employ sequential rounds but rather displays group responses to all participants immediately after they are generated. It differs from classic online surveys by providing real-time group feedback as the questionnaire is being completed so that the participants can learn from the group as the study progresses. The seminal paper on Real Time Delphi was published in 2006; and since then, several versions have been produced and used in a variety of applications (see Wikipedia "Real Time Delphi" and Gordon and Pease (2006)).

2.1.2 TREND IMPACT ANALYSIS (TIA)

TIA is a forecasting method that permits extrapolations of historical trends produced by curve fitting or other means (the baseline) to be modified in view of expectations about future external developments. This method permits an analyst, interested in forecasting a particular variable, to include and systematically examine the effects of possible future external developments that are believed to be important to the future course of the variable. The developments can include technological, political, social, economic, and/or value-oriented changes. The method requires that judgments be made about the probability of the developments, their timing and their impact on the variable under study. The steps in TIA include: producing a baseline extrapolation, producing a list of developments to be included in the analysis, estimating the probability of occurrence of each development and its potential effect on the variable; and then by using a Monte Carlo process, producing a series of mini-scenarios in which the developments are randomly decided and the variable adjusted accordingly.

2.2 TRADITIONAL TECHNIQUES

2.2.1 CURVE FITTING

The problem addressed in curve fitting is simple: how best to reproduce the historical course of a time series using an equation. The equation usually uses "year" as an independent variable, so it is possible to compute a value for the variable represented by the equation and to compare the computed value with the actual value. The object in curve fitting is to minimize the error between the actual and computed data points. Once a suitable equation has been identified, future years can be inserted into the equation and an extrapolation based on history becomes available. The problem is a common one, and there are many

available commercial packages that can handle this problem quite well. Typically, the software will have a battery of equations built-in including straight lines, parabolas, sinusoids, etc., and will—through iteration—attempt to identify which curve best approximates (or fits) the given data points. Statistical methods are used to measure goodness of fit , but the analyst must still use judgment in selecting a specific curve shape to use in forecasting, since even a good fit of historical data points can result in a forecast that is obviously impossible.

2.2.2 MONTE CARLO MODELING

Monte Carlo analysis is a means of simulating real-life processes that involve randomly determined outcomes. In our case, a large number of simulations are run; in each of these, a future year, beginning with the present and stepping forward a year at a time, is assumed. The developments are reviewed one at a time and each development is determined to have occurred or not according to a random number draw. If the probability of a development is higher than a random number between 0 and 1, it is assumed to occur. Then, in that simulation run, the variable under study is adjusted to account for the impact of the development. The process then moves on to the next year, and the remaining developments are decided and the impacts are adjusted in a manner similar to the prior year. This process of drawing random numbers, deciding the occurrence or nonoccurrence of the developments still in the inventory, and adjusting the variable to account for the occurrence of the developments is repeated to the end of the forecast interval. That constitutes a single run. The results are stored in a database and the process is repeated many times. The runs differ because different developments are decided to have occurred in different sequences in each run, according to the chance of random numbers. Our simulations were accomplished in an Excel macro, involved 100 runs and required about 5 seconds to complete a set of 100 runs.

Section 3: Quantitative Forecasts Based on Judgment

The RTD1 survey asked participants to provide direct estimates of the future values of the four variables. Participants were also asked to state what values they thought would be considered catastrophic, meaning an improbable downside expectation with a 1 in 200 chance of occurrence at the end of the 10-year period. Finally, the questionnaire asked for estimates of the mean reversion time for the four variables; mean reversion was defined as the tendency of a variable to return to an average or long-term trend after being disturbed. This section summarizes their quantitative responses received. Appendix B includes a copy of the RTD1 questionnaire.

Respondents were also asked to provide their rationales, including any personal biases they recognized. Section 7 provides examples of some of the insightful qualitative rationales they provided, and all rationales are listed verbatim in Appendix C.

3.1 DIRECT ESTIMATES

The following table summarizes the averages of responses (averages separately for each of three categories) and the number of responses (denoted N) received for high, most likely and low estimates of the four variables at three future points in time: two years (i.e., in 2022), five years (i.e., in 2025), and 10 years (i.e., in 2030).

Table 1
SUMMARY OF DIRECT ESTIMATES

CPI	2 Year	N	5 Year	N	10 year	N
High	4.34	22	5.84	19	7.98	20
Most Likely	2.28	22	2.79	19	3.05	20
Low	0.65	22	0.26	19	−0.27	20
10-year Treasuries						
High	4.35	20	6.39	19	8.68	19
Most Likely	2.79	20	3.32	19	4.08	19
Low	1.54	20	0.82	19	0.65	19
S&P 500						
High	15.18	17	18.37	17	23.01	18
Most Likely	3.15	17	4.64	17	7.13	18
Low	−13.78	17	−15.29	17	−14.10	18
Baa						
High	6.82	16	8.54	16	10.68	17
Most Likely	4.52	16	5.09	16	6.09	17
Low	2.46	16	2.03	16	1.24	17

While the estimates of the most likely values for the variables would seem to indicate belief by the participants in a relatively well-behaved economy, the more important message may be in the wide ranges, particularly at the 10-year mark.

3.2 CATASTROPHIC CONDITIONS

The penultimate question posed in RTD1 was designed to collect judgments about values and timing that the variables would have to achieve to be considered indicative of a financial catastrophe or crisis, such as a bubble, market crash or prelude to a panic. The question is first repeated here for convenience, then average responses are summarized in a table showing responses for two, five and 10 years. Responses about rationales are included in Appendix E.

It is worth noting that for all four variables, the bounds of catastrophe are well beyond the direct forecasts of the future values of the variables (e.g., compare Table 1 to Table 2).

Restatement of the question: *Consider catastrophic developments possible in the next 10 years.*

Using the form accessed from the column to the right, what plausible values of the four variables would be considered catastrophic and when might they occur?

Please enter the name of the variable and the high or low or both values that you think would indicate catastrophe and your judgment about timing. If you do not feel strongly on when the catastrophic event will occur in the 10-year Time Horizon, just add "na" to your answer.

Table 2
CATASTROPHIC VALUES

	2 yr-Hi	2 yr-Lo	5 yr-Hi	5 Yr.-Lo	10 yr-Hi	10 yr-Lo
CPI	>16.4%	<−1.8%	>19.5%	<−2.1%	>21.4%	<−2.1%
10 Yr. T's	>12.1%	<1.2%	>13.7%	<−1.0%	>13.8%	<−1.0%
S&P 500	>37.5%	<−34.0%	<37.5%	<−39.4%	>35.5%	<−39.4%
Corp Baa	>15.4%	<1.2%	>17.6%	<1.2%	>17.6%	<1.2%

3.3 REVERSION TO THE MEAN

The final question posed in RTD1 as designed to collect judgments about the time and rate of reversion to the mean of all four variables. The question is repeated here for convenience. A table is then presented that summarizes responses to the question.

Restatement of the question: *Using the form to the right, please provide your assumptions inherent in your earlier answers.*

Example: Assuming the current value of CPI is 3% and you think it will be 6% most likely in a reversion time of 15 years, the reversion speed would be (6-3)/15 or 0.2%/year.

Your answer would appear: For CPI: Reversion time= 15 years Reversion speed= 0.2% per year. Together with rationales and recognized biases. And repeated for the other three variables.

Table 3

REVERSION TO THE MEAN

	CPI	10 Yr. Treasury	S&P 500	Baa
	years	years	years	years
Average	25.36	22.50	33.00	28.33
Count	7	7	5	6

Considering the responses given for all four variables, the average reversion time is **27.3 years**. Too few responses were received to evaluate the reversion rate. Responses from at least five experts would have been required for each of both the times to revert and the reversion rates. The number of responses shown above represent participants who answered one aspect but not necessarily both. There were fewer than five responses for reversion rates.

Section 4: Quantitative Forecasts Based on Historical Data

This section deals with curve fitting and extrapolation. For each variable, the steps were: definition and search for reliable sources, extracting the data, fitting a curve to the data, and extrapolation. These steps form the basis for the tables that follow.

4.1 DEFINITION AND SOURCES

Table 4

DEFINITIONS AND SOURCES OF HISTORICAL DATA

Variable	Definition	Sources	URL
Annual change in the CPI	US city average not seasonally adjusted	Bureau Labor Statistics; series CUUR0000SA0	https://www.bls.gov/regions/new-england/data/consumerpriceindex_us_table.htm
10 Year Treasury Spot Par Yields	Market yield on U.S. Treasury securities at 10-year constant maturity, quoted on investment basis	Federal Reserve	https://www.federalreserve.gov/datadownload/Preview.aspx?pi=400&rel=H15&preview=H15/H15/RIFLGFCY10_N.A
S&P 500 Total Annual Rate of Return (i.e. return inclusive of dividends)	S&P 500 Total ROR	Macro Trends	https://www.macrotrends.net/2526/sp-500-historical-annual-returns
Corporate Baa Spot Yields (for 10-year tenors)	January 1 Moody's Seasoned Baa Corporate Bond Yield, Percent, Monthly, Not Seasonally Adjusted	Federal Reserve Economic Data (FRED)	https://fred.stlouisfed.org/series/BAA

4.2 EXTRACTING THE DATA

These sources yielded the following historical data as shown in Table 5.

Table 5

HISTORICAL DATA

	Consumer Price Index	10-Year Treasury	S&P 500 Total Annual Return	Corporate Baa Yields (10-year)
1997	2.3	5.26	31.01	8.09
1998	1.6	5.65	26.67	7.19
1999	2.2	6.03	19.53	7.29
2000	3.4	5.02	−10.14	8.33
2001	2.8	4.61	−13.04	7.93
2002	1.6	4.01	−23.37	7.87

2003	2.3	4.27	26.38	7.35
2004	2.7	4.29	8.99	6.44
2005	3.4	4.8	3.00	6.02
2006	3.2	4.63	13.62	6.24
2007	2.8	3.66	3.53	6.34
2008	3.8	3.26	−38.49	6.54
2009	−0.4	3.22	23.45	8.14
2010	1.6	2.78	12.78	6.25
2011	3.2	1.8	0.00	6.09
2012	2.1	2.35	13.41	5.23
2013	1.5	2.54	29.60	4.73
2014	1.6	2.14	11.39	5.19
2015	0.1	1.84	−0.73	4.45
2016	1.3	2.33	9.54	5.45
2017	2.1	2.58	19.42	4.66
2018	2.5	3.2	−6.42	4.26
2019	1.7	1.7	24.07	5.12

4.3 CURVE FITTING

As noted earlier, a commercial software package, CurveExpert Pro, 2.6., was used to fit the data. This software system is produced by Hyams Development and is described on its website as follows:

"CurveExpert Professional is a cross-platform solution for curve fitting and data analysis. Data can be modelled using a toolbox of linear regression models, nonlinear regression models, smoothing methods, or various kinds of splines. Over 90 models are built-in, but custom regression models may also be defined by the user. Full-featured publication-quality graphing capability allows thorough examination of the curve fit. The process of finding the best fit can be automated by letting CurveExpert compare your data to each model to choose the best curve. The software is designed with the purpose of generating high quality results and output while saving your time in the process."[1]

In practice, the data for a variable are fed into an Excel-like spreadsheet and the system proceeds to test its built-in models for best fit. The output is presented to the analyst who then must decide whether the fit is acceptable, generally based on the forecasts it yields. In our case, 20 years of historic annual data for the four variables were used in the CurveExpert application, and the software attempted to fit each of a set of

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[1] Hyams Development. CurveExpert Professional. *https://www.curveexpert.net/products/curveexpert-professional* (accessed April 26, 2020).

some 75 equations to the historical data points. The output presented the goodness of fit to each of the equations. Table 6 summarizes the selected equations, their parameters and the computed goodness of fit.

Table 6
BEST FIT EQUATIONS

	Consumer Price Index	10 Year Treasury	S&P 500 Total Annual Return	Corporate Baa Yields (10-year)
Curve Type	Sinusoidal	Sinusoidal	Truncated Fourier Series	Reciprocal Quadratic
Equation	a + b*cos(c*x + d)	a + b*cos(c*x + d)	a*cos(x+d) + b*cos(2*x + d) + c*cos(3*x + d)	x/(a + b*x + c*x^2)
Parameters				
a	2.14369	3.83952	7.64820	1918729.71948
b	0.74597	1.62961	−11.56240	−1920.47343
c	1.07670	0.16477	5.37655	0.48062
d	133.44882	−14.77623	−0.91606	na
Correlation Coefficient	0.53436	0.91398	0.52712	0.87025
Coefficient of Determination (r^2)	0.28554	0.83535	0.27785	0.85949

The final row of Table 6 presents the Coefficient of Determination (r^2), which is a statistical measure of the goodness of fit that runs from 0 to 1. The fits for 10-year Treasuries and Corporate Baa yields are excellent, but CPI and S&P 500 are not outstanding. See Section 6 for further discussion of the fit for S&P 500.

4.4 EXTRAPOLATION

In a preliminary review of these data, the POG suggested changing the forecast baseline for Corporate Baa yields to one derived from the panel's direct estimates, and this approach was used in the final analysis. With this change and the statistical analysis described earlier in this section, the baseline extrapolations are shown in Table 7.

Table 7
BASELINE EXTRAPOLATIONS

	Consumer Price Index	10 Year Treasury	S&P 500 Total Annual Return	Corporate Baa Yields (10-year)
2020	1.566	2.646	13.610	4.061
2021	1.454	2.844	3.150	3.893
2022	2.067	3.069	3.647	3.732
2023	2.761	3.315	4.309	3.578
2024	2.805	3.575	4.640	3.430
2025	2.154	3.843	5.138	3.289
2026	1.492	4.110	5.636	3.155
2027	1.515	4.370	6.134	3.027
2028	2.199	4.615	6.632	2.905
2029	2.825	4.840	7.130	2.789

Section 5: Quantitative Forecasts Based on Future Developments

A review of the rationales provided by participants in RTD1 resulted in a list of some 90 developments deserving further consideration. Through email exchanges and telephone discussions among the POG, the list consolidated down to 28 items for further consideration in RTD2. Table 8 lists these developments.

Table 8
TIA DEVELOPMENTS

	Developments
1	U.S. stabilizes its debt by monetizing all future deficits (government issues debt (bonds) to cover its spending, and the central bank purchases the debt from secondary markets, leaving the system with an increased supply of money).
2	The U.S. Federal Reserve is controlled by the executive branch.
3	U.S. defaults on its debt or pegs the U.S. dollar to gold at $10,000 level.
4	Amount of (global) government debt + corporate debt with negative interest rates (as percentage of all debt) reaches 33%.
5	U.S. economy enters a period that economists call a "liquidity trap."
6	U.S. economy enters a period that economists call stagflation.
7	Guaranteed minimum income established in U.S. and most other OECD countries is at 25% above poverty level.
8	Federal debt to GDP ratio reaches 150%.
9	Federal debt to GDP ratio reaches 50%.
10	U.S. taxation increased to a level that balances the budget.
11	Carbon tax is implemented worldwide.
12	E.U. fails and countries/currencies regain independence.
13	U.S. adopts single-payer health care.
14	Wealth inequality—the dozen countries with the highest current wealth gap between richest and poorest people enact political and economic reforms designed to close the gap within three years.
15	National elections in the U.S. become chaotic to the extent that violence often erupts quelled by armed force.
16	Trade tariffs and currency wars double in number and size in relation to 2019 levels.
17	Tariff and trade wars are resolved.

18	U.S. enters armed conflict with one or more major nations.
19	Incumbent loses reelection in 2020; U.S. policies revert to former era.
20	Major hack cripples the financial system for one month; 50% of individual depositors and corporations cannot reconstruct the amounts in their accounts; stock trades must be documented by hand.
21	There is rapid growth of the use of robotics and artificial intelligence in major economies worldwide; machines take over one-third of today's jobs.
22	The price of oil drops below $30 for more than a year.
23	Climate change initiatives prove to be ineffective, food prices increase so much that there is food insecurity for one-third of Americans.
24	Perceived life expectancy at birth in the U.S. increases to 90 years.
25	Pandemic kills 1% of the world population (Spanish flu of 1918 is estimated to have killed between 50 and 100 million people worldwide).
26	Natural disaster kills 100,000 in the U.S. (e.g., earthquake in Los Angeles or Puget Sound)
27	Massive terror attack kills more than 10,000 people in the U.S.
28	Space travel becomes economical for 10% of U.S. citizens.

The Questionnaire (Appendix B) requested participants to provide judgments about probabilities of these developments 10 years hence and their expected impacts on the four variables. This information is required in the TIA that follows.

The questionnaire also included a space for participants to add other developments that they thought deserved consideration. Participants who followed them could see and comment on these added developments.

5.1 AVERAGE IMPACT PARAMETERS AND NUMBER OF RESPONSES

Table 9 summarizes the group's responses to questions about the impacts of the developments on the variables. The questionnaire asked for judgments about:

1. The probability of the developments: "What is the percentage likelihood of the onset or occurrence of this development before 2030?"
2. The year of maximum impact: "In what year do you believe the development will have its maximum impact on the variables?"
3. The size of the maximum impact: "How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter –.5."

The numbers in parentheses in these tables is the number of responses received.

Table 9
SUMMARY OF RESPONSES ON DEVELOPMENTS

	Developments	Likeli-Hood Percent	Year of max impact	Impact on CPI	Impact on 10 yr Treasury	Impact on S&P	Impact on Baa
1	U.S. stabilizes its debt by monetizing all future deficits.	21.0 (19)	2028 (10)	13.6 (11)	8.5 (11)	−13.7 (12)	6.5 (10)
2	The U.S. Federal Reserve is controlled by the executive branch.	11.2 (17)	2023 (6)	5.5 (5)	5.8 (5)	−4.4 (4)	1.3 (3)
3	The U.S. defaults on its debt or pegs U.S. dollar to gold at $10,000 level.	6.1 (15)	2029 (5)	4.7 (5)	3.1 (5)	−14.2 (5)	4 (4)
4	Amount of debt with negative interest rates (as percentage of all debt) reaches 33%.	11.8 (17)	2031 (8)	2.8 (9)	−1.2 (8)	−4.5 (8)	−0.6 (7)
5	U.S. economy enters a period that economists call a "liquidity trap."	32.3 (18)	2025 (14)	−1.5 (11)	−1.4 (10)	−11.5 (10)	0.3 (10)
6	U.S. economy enters a period that economists call stagflation.	19.3 (18)	2026 (12)	8.0 (8)	4.6 (7)	−16.0 (7)	3.6 (7)
7	Income inequality—guaranteed minimum income established in U.S. and most other OECD countries is at 25% above poverty level.	15.9 (17)	2029 (12)	2.2 (7)	1.8 (7)	1.0 (7)	1.4 (7)
8	Federal debt to GDP ratio reaches 150%.	30.6 (15)	2032 (13)	3.8 (9)	3.8 (9)	−4.2 (9)	3.3 (9)
9	Federal debt to GDP ratio reaches 50%.	7.7 (15)	2037 (4)	−2.5 (2)	0.5 (2)	6.0 (2)	−2.0 (2)
10	U.S. taxation increased to a level that balances the budget.	6.7 (17)	2033 (5)	0.3 (6)	1.1 (6)	1.6 (6)	0.4 (6)

11	Carbon tax is implemented worldwide.	20.9 (16)	2030 (10)	0.8 (6)	0.4 (6)	−0.1 (6)	1.0 (6)
12	E.U. fails and countries/currencies regain independence.	23.2 (16)	2028 (9)	1.1 (6)	0.3 (6)	3.3 (6)	1.0 (6)
13	The U.S. adopts single-payer health care.	20.6 (17)	2028.1 (9)	1.0 (5)	1.0 (5)	−3.6 (5)	4.0 (5)
14	Wealth inequality—the dozen countries with the highest current wealth gap between richest and poorest people enact political and economic reforms designed to close the gap within three years.	9.4 (15)	2029 (5)	1.5 (4)	1.0 (4)	0.8 (4)	0.6 (4)
15	National elections in the U.S. become chaotic to the extent that violence often erupts quelled by armed force.	18.2 (15)	2021 (8)	4.4 (6)	2.8 (5)	−21.7 (6)	1.8 (5)
16	Trade tariffs and currency wars double in number and size in relation to 2019 levels.	19.5 (15)	2025 (9)	1.9 (8)	0.8 (8)	−11.6 (8)	1.8 (8)
17	Tariff and trade wars are resolved.	23.3 (16)	2023 (5)	−0.8 (5)	0.4 (5)	9.4 (5)	-0.3 (5)
18	The U.S. is in armed conflict with one or more major nations.	25.9 (14)	2025 (5)	4.2 (6)	5.2 (6)	-14.5 (6)	3.4 (5)
19	Incumbent loses reelection in 2020; U.S. policies revert to former era.	47.6 (14)	2021 (9)	0.9 (8)	0.9 (8)	−7.3 (9)	1.3 (8)
20	Major hack cripples the financial system for one month; 50% of individual depositors and corporations cannot reconstruct the amounts in their accounts; stock trades must be documented by hand.	18.1 (15)	2028 (6)	5.7 (5)	3.9 (5)	-25.5 (6)	2.9 (5)
21	There is rapid growth of the use of robotics and artificial intelligence in major economies worldwide;	37.1 (17)	2032 (10)	-0.6 (6)	-0.5 (6)	5.3 (7)	1.3 (6)

#	Development						
	machines take over one-third of today's jobs.						
22	Price of oil drops below $30 for more than a year.	11.9 (16)	2029 (8)	−0.3 (6)	−0.2 (5)	4.2 (6)	0.8 (5)
23	Climate change initiatives prove to be ineffective; food prices increase so much that there is food insecurity for one-third of Americans.	34.1 (16)	2030 (8)	3.2 (6)	1.0 (6)	−10.7 (7)	1.9 (6)
24	Perceived life expectancy at birth in the U.S. increases to 90 years.	25.3 (17)	2034 (8)	0.6 (6)	0.6 (6)	2.0 (7)	0.3 (6)
25	Pandemic kills 1% of the world population (Spanish flu of 1918 is estimated to have killed between 50 and 100 million people worldwide).	12.5 (17)	2031 (5)	1.9 (4)	0.5 (4)	−15.4 (5)	1.1 (4)
26	Natural disaster kills 100,000 in U.S. (e.g., earthquake in Los Angeles or Puget Sound).	18.0 (16)	2034 (7)	2.2 (6)	0.8 (6)	−12.5 (6)	1.7 (6)
27	Massive terror attack kills more than 10,000 people in the U.S.	18.1 (17)	2030 (6)	0.8 (5)	0.8 (5)	−13.3 (6)	0.4 (5)
28	Space travel becomes economical for 10% of U.S. citizens.	2.9 (17)	2036 (5)	2.0 (3)	0.7 (3)	8.0 (4)	0.8 (3)

As can be seen, the panelists felt the three most likely developments were (but all were less than 50/50):

	Likelihood
19. Incumbent loses reelection in 2020; U.S. policies revert to former era.	47.6 (14)
21. There is rapid growth of the use of robotics and artificial intelligence in major economies worldwide; machines take over one-third of today's jobs.	40.3 (15)
23. Climate change initiatives prove to be ineffective; food prices increase so much that there is food insecurity for one-third of Americans.	35.4 (14)

And the three least likely developments were judged to be:

	Likelihood
28. Space travel becomes economical for 10% of US citizens.	2.9 (15)
3. The U.S. defaults on its debt or pegs U.S. dollar to gold at $10,000 level.	6.1 (15)
10. U.S. taxation increased to a level that balances the budget.	6.7 (17)

The developments judged to increase the CPI the most were:

	Likelihood	Impact
1. U.S. stabilizes its debt by monetizing all future deficits.	21.0 (19)	13.6 (11)
6. U.S. economy enters a period that economists call stagflation.	19.3 (18)	8.00 (8)

And the developments judged to decrease the CPI the most were:

	Likelihood	Impact
9. Federal debt to GDP ratio reaches 50%.	7.7 (15)	−2.5 (2)
5. U.S. economy enters a period that economists call a "liquidity trap."	32.3 (18)	−1.5 (11)

The developments judged to increase the 10-year Treasury spot yields the most were:

	Likelihood	Impact
1. U.S. stabilizes its debt by monetizing all future deficits.	21.0 (19)	8.5 (11)
2. The U.S. Federal Reserve is controlled by the executive branch.	18.1 (17)	5.8 (5)

The developments judged to decrease the 10-year Treasury spot yields the most were:

	Likelihood	Impact
5. U.S. economy enters a period that economists call a "liquidity trap."	32.3(18)	−1.4 (10)
4. Amount of debt with negative interest rates (as percentage of all debt) reaches 33%.	11.8 (17)	−1.2 (8)

The developments judged to increase the S&P 500 rate of return the most were:

	Likelihood	Impact
17. Tariff and trade wars are resolved.	23.3 (16)	9.4 (5)
28. Space travel becomes economical for 10% of U.S. citizens.	2.9 (17)	8.0 (4)

The developments judged to decrease the S&P 500 rate of return the most were:

	Likelihood	Impact
20. Major hack cripples the financial system for one month; 50% of individual depositors and corporations cannot reconstruct the amounts in their accounts; stock trades must be documented by hand.	18.1 (15)	−25.5 (6)
15. National elections in the U.S. become chaotic to the extent that violence often erupts quelled by armed force.	18.2 (15)	−21.7 (6)

The developments judged to increase the Corporate Baa yields the most were

	Likelihood	Impact
1. The U.S. stabilizes its debt by monetizing all future deficits.	21.0 (19)	6.5 (10)
13. The U.S. adopts single-payer health care.	20.6 (17)	4.0 (5)

The developments judged to decrease the Corporate Baa yields the most were

	Likelihood	Impact
9. Federal debt to GDP ratio reaches 50%.	7.7 (15)	−2.0 (2)
4. Amount of debt with negative interest rates (as percentage of all debt) reaches 33%.	11.8 (17)	−0.6 (7)

Some observations from these lists:

- There were no sure things; all developments were rated as less than 50% probable.

- The first listed development, "US stabilizes its debt by monetizing all future deficits," was identified as having the potential to cause the greatest increase on 3 out of the 4 variables.

- Considering all four variables. the average number of people who provided judgments about probability of occurrence was 16; for year of maximum impact the number was 8; and for level of impact the number was 6.

- Two developments were seen as having the potential to cause the greatest decrease on two of the variables; these were "4. Amount of debt with negative interest rates (as percentage of all debt) reaches 33%" and "9. Federal debt to GDP ratio reaches 50%."

- The development seen as having the potential to cause the greatest decrease on any variable was "20. Major hack cripples the financial system for one month" on S&P 500 variable.

- The development whose impact was seen to be most immediate was "19. Incumbent loses reelection in 2020: U.S. policies revert to former era"; and the development that was seen as having the longest time to its maximum impact was "3. U.S. defaults on its debt or pegs U.S. dollar to gold at $10,000 level."

Section 6: TIA Forecasts

A TIA was run based on the probabilities and impacts of the developments and the extrapolations of the historical data. The process has been described in Sections 2 and 9 and in Appendix D. The TIA's Monte Carlo program produced 100 mini scenarios each time it was run: in Figures 2-7, the upper quartile is defined as the point at which 25 of the mini-scenarios lie above and 75 below. Similarly, the lower quartile is defined as the point at which 25 of the mini-scenarios lie below and 75 above. At the median, half the mini-scenarios lie above and half below. In all of these figures, the three data points shown for the year 2030 are the average of the direct estimates of high, medium and low expert judgments from RTD1 and show data from Section 3 graphically.

The TIA produced estimates of the four variables that appear below.

Figure 2
ANNUAL CHANGE IN THE CONSUMER PRICE INDEX
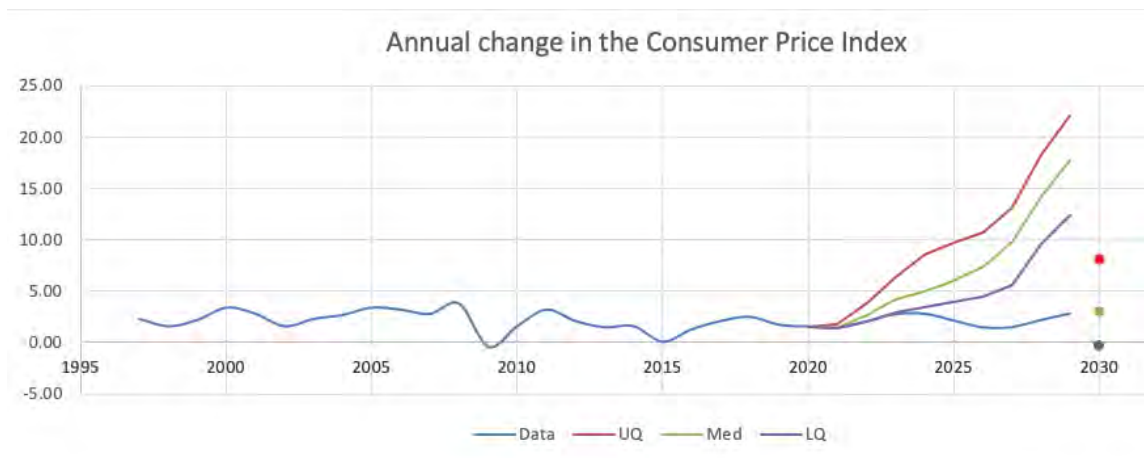
The CPI has been at historical lows recently, and the baseline forecast shows that that tendency continues for the next decade. But the developments considered in RTD2 tend to increase the prospects for inflation. The upper quartile value of the CPI produced by the Monte Carlo process rose to a level of 22% by 2029. For comparison, the highest rate since the CPI was introduced in 1913 was 19.66% in 1917.[2]

Many of the economic actions initiated to reduce the economic consequences of the COVID-19 pandemic seem to be inflationary, and the forecasted rise in the CPI seems to be consistent with that possibility. This is remarkable, since this study was conducted before the COVID-19 pandemic developed, but the apparent foresight may be only coincidental.

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[2] Beers, Brian. What's the Highest Inflation Rate in U.S. History? *Investopedia*, June 25, 2019, https://www.investopedia.com/ask/answers/112714/whats-highest-yearoveryear-inflation-rate-history-us.asp (accessed February 4, 2020).

Figure 3
10-YEAR TREASURY SPOT PAR YIELDS
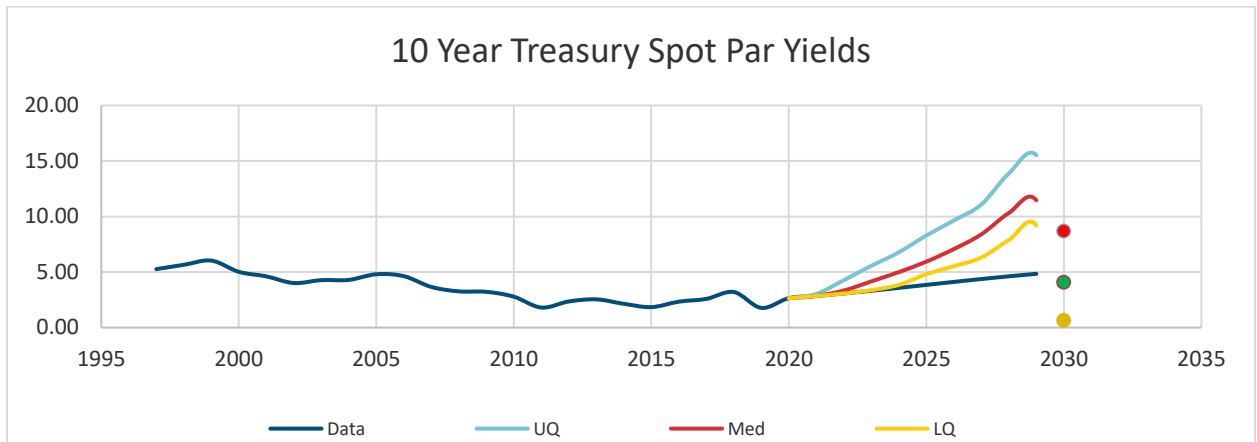
Similarly, 10-year Treasury spot par yields are to rise above the baseline projection as the inflation forecasts. Inflation implied by the previous variable, CPI means that the payoff of mature bonds these government bonds will be in cheaper dollars. Since 2000, 10-year Treasury yields have ranges between 6% and current low values of 1.0%.

Figure 4
S&P 500 TOTAL ANNUAL RATE OF RETURN
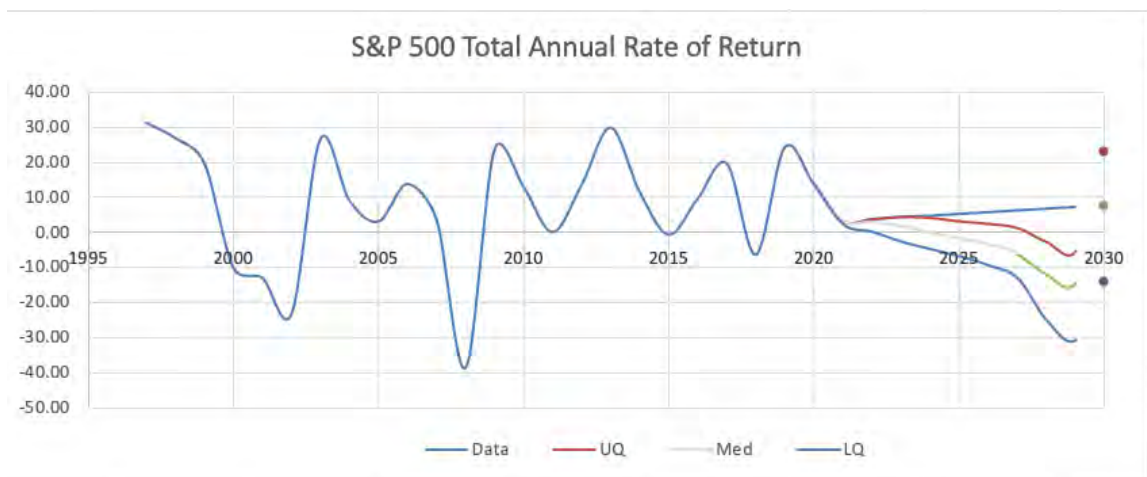
As noted in Section 4.4 the usual extrapolation procedure of historical S&P 500 data was replaced with the judgments of forecasts made by panelists in RTD1. The curve fitting procedure led to a selection of an unusual equation: a truncated Fourier series with the following characteristics, as shown in Table 10.

Table 10
CHARACTERISTICS OF EQUATION FOR S&P 500 ANNUAL RATE OF RETURN

Equation	a*cos(x+d) + b*cos(2*x + d) + c*cos(3*x + d)
Parameters	
a =	7.64820
b =	-11.56240
c =	5.37655
d =	-0.91606
Standard Error	18.05732
Coefficient of Determination (r^2)	0.27785

And graphically, as shown in Figure 5.

Figure 5
S&P 500 TOTAL ANNUAL RATE OF RETURN
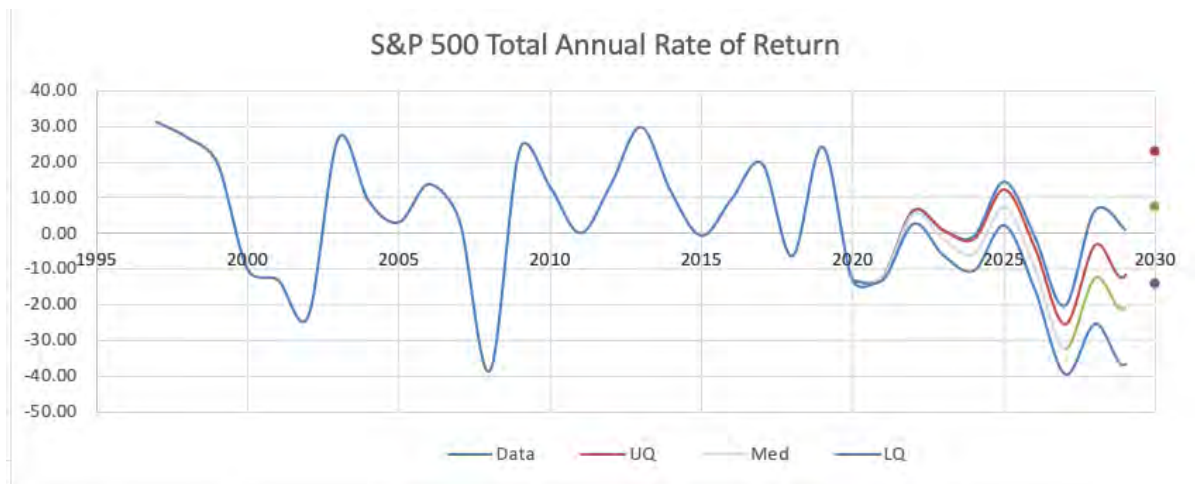
Regardless of which approach is employed, the effects on the baseline and the forecast are clear: The uncertainty is high; and by 2029, the rate of return may be in the range of +10% to −35%. Is this unprecedented? The extremes were greater than +/− 45% in the early 1930s and more recently +31% in 1975 and −38% in 2008.

Figure 6
CORPORATE BAA SPOT YIELDS (1O-YEAR TENORS)(JAN)

Corporate Baa Spot Yields (10-year tenors)(Jan)
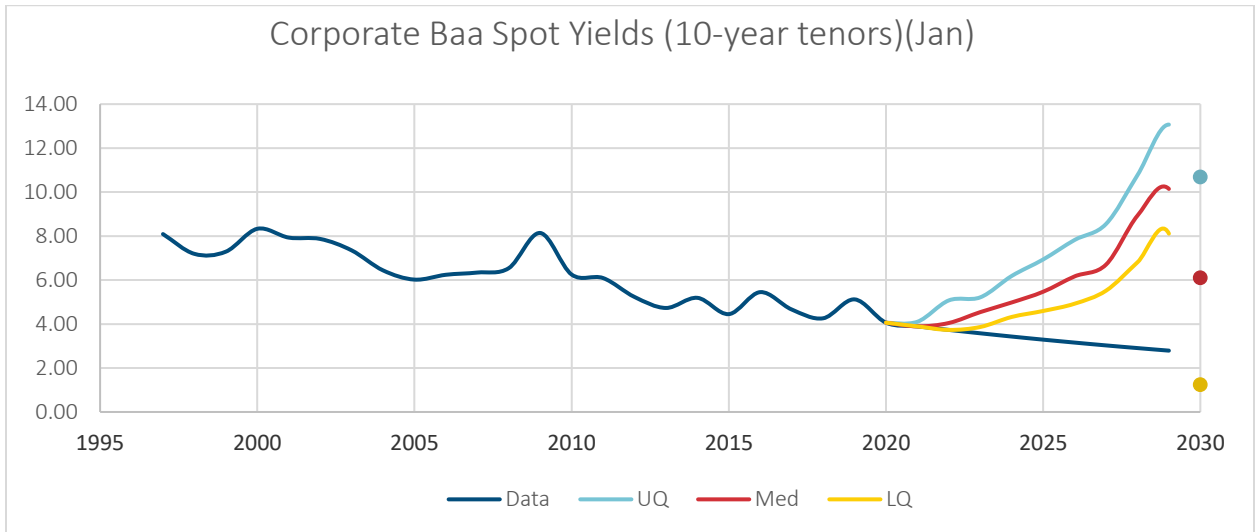
In this economic environment, borrowers will have to pay more to obtain capital—hence bonds, particularly more risky bonds, will require promises of higher return. Historically, Baa corporate bond yield has been as high as 17.18% in 1982 and as low as 2.94 in 1946. It is currently at about 3.5%

Section 7: Qualitative Responses

Appendix C presents the rationales provided by participants underlying their quantitative entries. This Section presents a selected small sampling of the extensive narrative material that was generated.

Appendix C contains a wealth of insights and perceptions about the complex interconnectedness of elements of the political/economic/social systems that make up our world. There is some consistency in these perceptions. The following table indicates how many responses contained certain key words among the 86 rationales of RTD1 and the 212 rationales of RTD2.

Table 11
FREQUENCY OF KEY WORDS

Rank	Key word or term	Number of responses with this word
1	inflation	47
2	US	34
3	Economy/economic	32
4	debt	23
5	risk	22
6	war	21
7	Trump	15
8	trade	15
9	tax	13
10	EU/Europe	12
11	policy	11
12	China	10
13	climate	10
14	uncertainty	10
15	credit	9
16	default	8
17	markets	7
18	terror	4
19	energy	4
20	privacy	2

While this list indicates what may have been on the minds of participants, these counts should be treated with skepticism. The words listed here may simply reflect the way questions were posed and headlines of the moment.

One provocative rationale example is presented below for each question in RTD1 and RTD2; the complete set is contained in Appendix C. These quotes are not meant to be representative of the responses, only illustrative.

7.1 FROM RTD1

Rationales for responses to Question 1.
Annual Changes in Consumer Price Index (YoY)

4. A combination of elements outside the control of the Fed are likely to increase CPI beyond what we can foresee today. Increasing consumerism globally as a result of growing middle class in emerging economies (e.g., China) will most likely lead to rising prices in North America for many products. Food prices are expected to rise considerably, given the combination of increasing demand (growing population with increasing purchase power), the impacts of climate change that will reduce production scale, and the increasing reliance on local sources. These will impact all the other prices. Monopoly combined with increasing demand for rare earth elements /materials (or rare anything) while they become less available given climate change will impact prices for high-tech and renewables.

Rationales for responses to Question 2.
10-year U.S. Treasury yield

27. Low inflation will force short-term interest rates to stay low. Extremely strong demand for safe product will continue to drive maturity premium lower. Foreign demand for U.S. assets will pressure down U.S. yields. Both result in 10-year yields unable to breach above the local maximum reached in 2018. Debt and fiscal risk will not be a concern incorporated in the Treasury market.

Rationales for Responses to Question 3.
S&P 500 Total ROR

37. I could see catastrophic events tripping up the stock market. I could also see investor sentiment becoming a problem at some point. For now, I think the odds of a recession are very low. I think the earnings for corporations will remain strong. I also think the tariff and trade wars will be resolved during the coming election year. Longer term, I expect increases in taxes and pressure on corporate earnings due to competition globally. I also see the costs of addressing climate change and other social pressures coming to bear on corporate profits.

Rationales for Responses to Question 4.
Corporate Baa Spot Yields

59. Credit spreads will stay tight for the next two years but widen after that as concerns about credit exposure increase. Low value would require very low inflation and a very soft impact from end of credit cycle. If credit cycle end is more difficult, high value will go back to the values experienced in 2008.

7.2 FROM RTD2

Question 1. U.S. stabilizes its debt by monetizing all future deficits.

4. It is easier to monetize than to make difficult political choices. Since dealing with the deficit will be forced on the federal government, it is natural to take the path of least resistance.

Question 2. The U.S. Federal Reserve is controlled by the executive branch.

18. An international financial chaos triggered or increased by Chinese growing power, mismanagement of the European Central Bank and a fast devaluation of the USD might ask for very drastic measures.

Question 3. U.S. defaults on its debt or pegs U.S. dollar to gold at $10,000 level.

27. May be selective default to only foreign borrowers—likely requires war as a driver.

Question 4. Amount of debt with negative interest rates (as percentage of all debt) reaches 33%.

33. For the U.S. to issue debt with interest rates lower than actual or anticipated inflation would require a situation involving a sudden spike in inflation (e.g., war, virtual failure of financial system, etc.) or the rise of interest rates in a foreign country with stable economics and prospects that gives U.S. paper competition.

Question 5. U.S. economy enters a period that economists call a "liquidity trap."

43. 2008 did not improve transparency enough, and now shadow banks are picking up the banking slack with even less transparency.

Question 6. U.S. economy enters a period that economists call stagflation.

51. This would be a bifurcation from where we are now, but it does not take much to force a revision of expectations, and it is a widespread expectation of persistent inflation that leads to stagflation. If a change in fiscal policy caused a loss of faith in savings vehicles and accelerated inflation, that would be a catalyst.

Question 7. Guaranteed minimum income established in U.S. and most other OECD countries at 25% above poverty level.

61. If it happens before 2030, likely to be right after 2024 election with a one-issue candidate focused on inequality.

Question 8. Federal debt to GDP ratio reaches 150%.

73. Higher rates, especially corporate borrowing rates, are probable under such a scenario. However, we should remember that Japan has a debt to GDP ratio today over 200% and has managed to keep rates low. The devastation will come, but timing can be long in the tooth.

Question 9. Federal debt to GDP ratio reaches 50%.

76. What did we do to make this happen?

Question 10. U.S. taxation increased to a level that balances the budget.

81. I don't see this happening in my lifetime, unless the world's financial system blows up first and this becomes required in the aftermath.

Question 11. Carbon tax is implemented worldwide.

90. If extreme events continue to get worse, this will be implemented along with other voter inequality measures. Carbon tax, taken further to reflect usage of scarce resources, is necessary as a minimum

measure to clean up the atmosphere and general environment. This is a problem of double entry accounting that the accountants should fix.

Question 12. The E.U. fails and countries/currencies regain independence.

98. E.U. failing means loss of central bank and coordinated economic policy. We were close in 2010, and the negative rates policies in the E.U. are starting to be seen as the failures that they are. If E.U. GDP growth cannot be revived, failure is not far behind.

Question 13. The U.S. adopts single-payer health care.

103. Wishful thinking, but the 20% of Americans that oppose it are way more influential than the 80% that support it.

Question 14. Wealth inequality—the dozen countries with the highest current wealth gap between richest and poorest people enact political and economic reforms designed to close the gap within three years.

112. No way to deal with an effect that is a consequence of normal economic forces. The one exception is China, where it is largely the result of corruption, and unrest could take a toll.

Question 15. National elections in the U.S. become chaotic to the extent that violence often erupts quelled by armed force.

119. If Trump declares that anti-Trump attitudes are treasonous.

Question 16. Trade tariffs and currency wars double in number and size in relation to 2019 levels.

124. When E.U. and U.S. politicians will realize the level of impact of Chinese power on the financial, economic and political order, drastic measures might be implemented.

Question 17. Tariff and trade wars are resolved.

129. Unlikely because they have become an instrument of foreign policy. Why are other respondents so optimistic; has it ever happened? Is it more or less likely in our world and time? Yet Trump may see this as a useful instrument in his re-election bids.

Question 18. There is U.S. armed conflict with one or more major nations, involving more than 50,000 U.S. troops.

134. China or Iran are serious possibilities for conventional conflict. In the case of North Korea, I fear it would be weapons of mass destruction. Other regions could erupt such as the Middle East.

Question 19. Incumbent loses reelection in 2020; U.S. policies revert to former era.

146. 4Q2020 after the election but before inauguration will be a wild time if Trump loses. Otherwise next four years will be crazy as lame duck president.

Question 20. Major hack cripples the financial system for one month; 50% of individual depositors and corporations cannot reconstruct the amounts in their accounts; stock trades must be documented by hand.

152. Some effects would be lasting (e.g., distrust of online transactions); others temporary, say one year to recovery; consequence would be further tightening of internet and penalties for hackers. But as I noted, some effects would be lasting. In my answers here, I have shown the long-term guesses; the short-term values would be (guess) twice as high.

Question 21. Rapid growth of the use of robotics and artificial intelligence in major economies worldwide; machines take over one-third of today's jobs.

159. The real change and the real uncertainty comes with the evolution of this technology to general artificial intelligence. This is the transition that Hawkings and Musk and many others have warned about—it is a transition when machines can indeed take over or move us to a new intellectual and social plateau.

Question 22. Price of oil drops below $30 for more than a year.

164. Why does this development happen? Three possibilities: more oil deposits discovered, alternate fuels meet the demand for energy, or price cutting among suppliers: all plausible.

Question 23. Climate change remediation programs prove to be ineffective; food prices rise 20%.

172. A tipping point is coming as jet stream becomes weak, initially cooling northern climates as warmth enters Arctic and Gulf Stream weakens, then warming everywhere. Hard to predict dates.

Question 24. Perceived life expectancy at birth in the U.S. increases to 90 years.

175. There will be many people living with the expectation of living past the age of 90, which will change behavior with respect to savings, annuities, Social Security. But they may not live that long.

Question 25. Pandemic kills 1% of the world population (Spanish flu of 1918 is estimated to have killed between 50 and 100 million people worldwide).

188. Although the Spanish flu of 1918 did indeed kill millions, the happy years of the flapper of the 1930s followed. The dead were buried and life went on. My answers have assumed the same kind of socio-economic response. But certainly in the midst of the pandemic, things would slow, pessimism would reign.

Question 26. Natural disaster kills 100,000 in U.S. (e.g. earthquake in Los Angeles or Puget Sound).

192. This one of those events that have a flat probability curve. Any time is as likely as any other. However, mitigating the impact is the possible development of predictive technologies.

Question 27. Massive terror attack kills more than 10,000 people in the U.S.

194. Terrorists are looking for a spectacular show that exceeds 9/11. Artificial biological epidemics may be their weapon, so I judge this as plausible. Even a subway attack at rush hour could do it. It would be three times larger than 9/11.

Question 28. Space travel becomes economical for 10% of US citizens.

200. Ten percent is too high. Implies about 40,000,000 space tourists. Wow! And implies a ticket price of under say $250. Even if we are talking about a ballistic flight to 100,000 feet above the earth, this development would be hard to imagine.

Respondents were also asked to suggest other developments that could cause impacts as significant as those contained in the given set; here are those new suggestions. (Developments that have already been decided have been omitted, e.g., Guilty in an impeachment trial.).

Table 12
OTHER DEVELOPMENTS SUGGESTED BY RESPONDENTS

Digital currencies	Hyper-connectivity (of all things and people) ensures a complete lack of privacy.
Chinese socialism fails.	A large segment of the population elects to go off the grid, forcing a dramatic shift in community dynamics, workforce solutioning, food security and more.
Regional wars are driven by climate change.	Gig working grows in popularity and leads to millions being employed fully but under-protected by traditional employer-provided safety nets (e.g., health insurance, life insurance and retirement benefits, to name a few).
E.U. gets irrevocably under Chinese influence, as do Latin America and Africa.	Migration and immigration trends
China blows up—due to economic and social factors.	Other decentralized means of transaction (voting)
New nuclear energy tech	Underrepresented populations gain political traction and force leading to shifts in systemic regulations and increased access to economic means for more citizens.
The U.S. government is overthrown or is turned into a dictatorship.	Ocean level (changes)
Fresh water availability	

Section 8: Example of Use in Sensitivity Testing

The TIA model consisting of the list of developments, their probabilities and impacts, and the extrapolations of historical data can be used to test the consequences of "what if" assumptions. For example, the set of assumptions that make up the model leading to the economic forecasts shown in Section 6 produces a median forecast for CPI of about 15% in 2029. But suppose we want to determine the consequence of election violence in the U.S. on the value of these variables. Changing a single element in that model, say the assumed probability of development "15. National elections in the U.S. become chaotic to the extent that violence often erupts quelled by armed force" from its value of 22.86% to 100%, yields different outcomes, as follows:

Table 13
COMPARISON OF TWO CASES

	CPI	10 Yr TR	S&P	Corp Baa
Case 1	14.82	9.83	−17.77	9.68
Case 2	20.23	12.70	−23.35	11.89

Where: Case 1 is the "standard model" in a set of 100 Monte Carlo runs described in the previous sections and the probability of development 15 is 22.86%. Case 2 is identical except that the probability of development 15 is 100%.

If one were making an argument for avoiding violence in elections, then the model would suggest that "inflation would soar to near record highs, Treasury bill rates would increase by almost 50%, the markets would fare badly, and junk bonds could be worth a look." (Note that there are many ways for avoiding violence during elections that have nothing to do with economics but that relate to tranquility in a free society.)

Section 9: Visualizing the Monte Carlo Runs

To explain the Monte Carlo process used in this study, begin by imagining that a single variable is being forecasted, say the CPI. (The other three variables will follow the same process.) The analysis starts with a baseline forecast of CPI in hand; usually this is an extrapolation of historical data. In addition, from RTD2, we can derive estimates of the probabilities of the developments and their potential consequences for CPI.

All of the following steps are automated in the Monte Carlo program. Imagine moving forward one year into the forecast period. Random numbers are produced by the program and compared to the probabilities of each of the developments at that time. If a development's probability is higher than the random number, the development is assumed to have "occurred," and a consequent adjustment to the CPI baseline is computed. The program moves ahead to year two of the forecast interval. The remaining developments are decided and further adjustments to the baseline are computed. A single mini-scenario is constructed in this way for CPI.

The Monte Carlo program repeats this process 100 times; each time is likely to produce a different mini-scenario in terms of which developments occur and when, since the occurrences are determined by fresh random number draws. Figure 7 shows the first five of the set of 100. If all 100 were plotted, we would see a "fan" of future expectations and the median and quartiles could be calculated. Using the Monte Carlo code developed for the Excel macro program, 100 runs for the four variables takes fewer than 5 seconds. See Appendix D4 for a further description of the Monte Carlo approach.

Figure 7
ANNUAL CHANGE IN CONSUMER PRICE INDEX FIRST FIVE MONTE CARLO RUNS
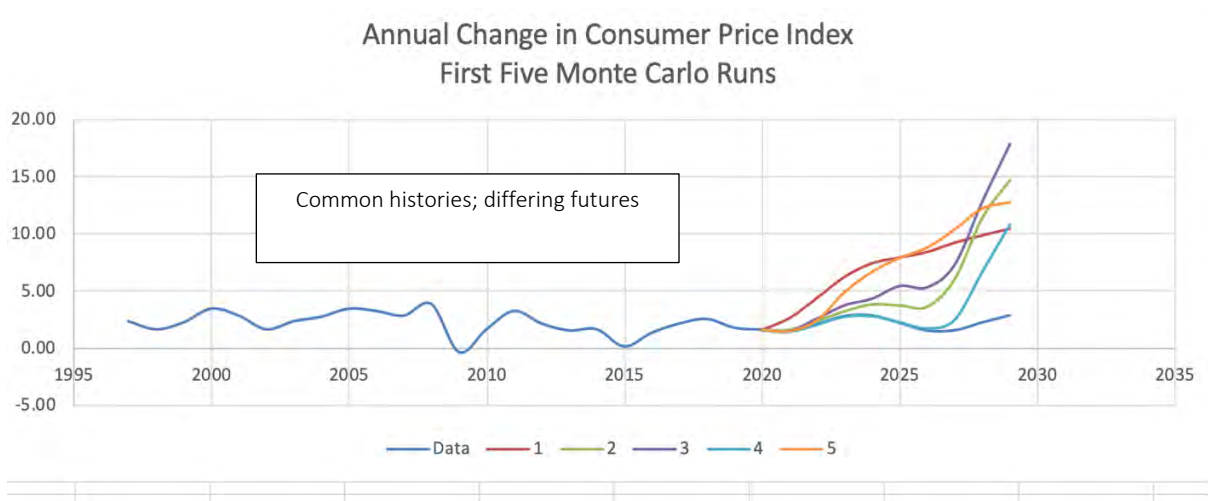
To further illustrate the notion that the Monte Carlo process produces a fan of forecasts from which interquartile ranges and other statistical characteristics can be identified, a series of cross-sectional histograms was produced using Excel. These histograms show the changes to the baseline (extrapolation) of the CPI variable introduced by the developments for 100 runs at three future times: 2021, 2024 and 2029. The X axis shows the magnitude of the changes to the baseline caused by the developments, and the Y axis shows the number of runs in which these changes occurred. The areas within these histograms are

identical: 100 runs. Two features are apparent: the spread with time and the increasing magnitude of the change caused by the developments.

Figure 8

DISTRIBUTION OF CHANGES TO MINI-SCENARIO BASELINE VARIABLE: CPI, YEAR 2021
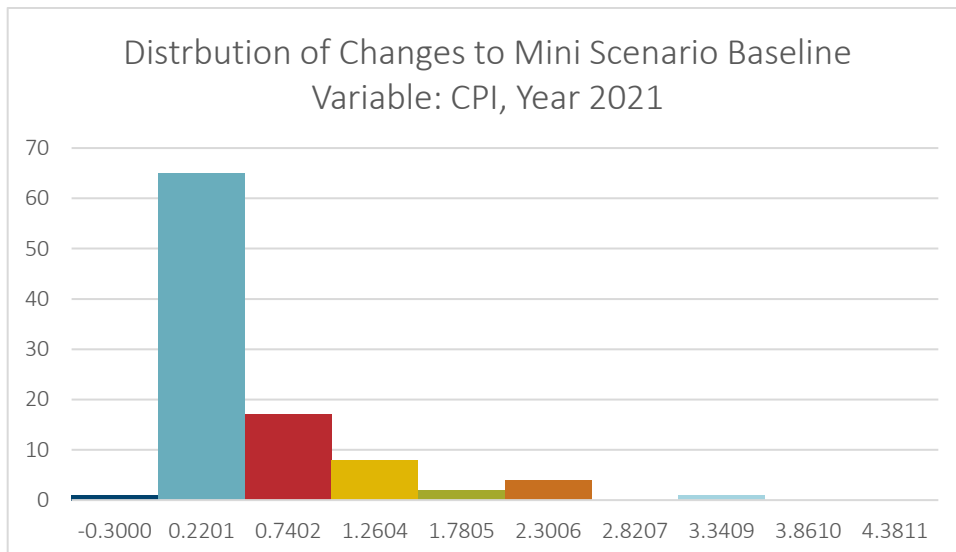
Figure 9

DISTRIBUTION OF CHANGES TO MINI-SCENARIO BASELINE VARIABLE: CPI, YEAR 2024
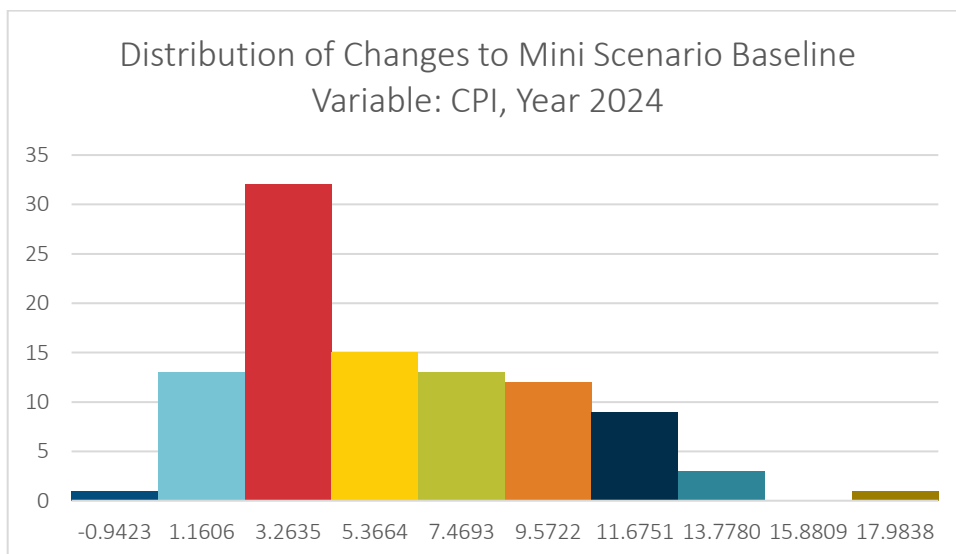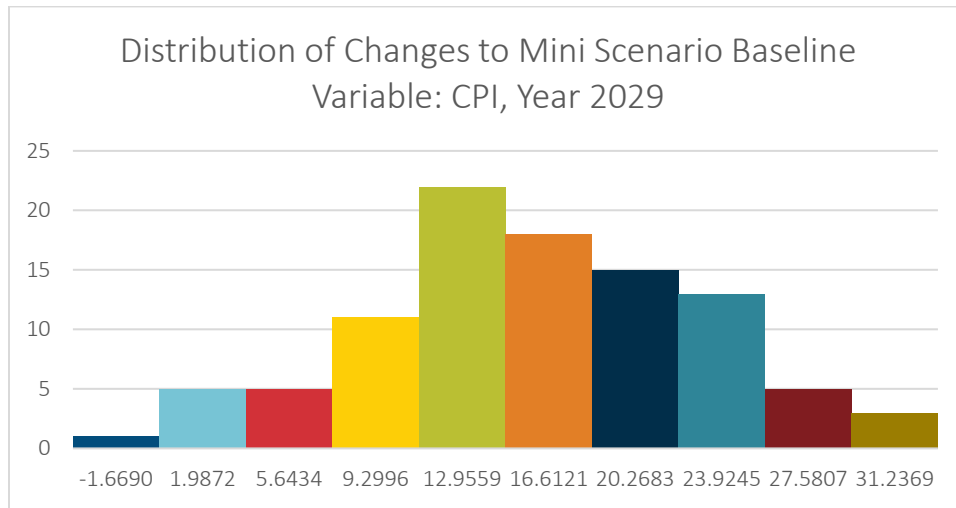
Figure 10
DISTRIBUTION OF CHANGES TO MINI-SCENARIO BASELINE VARIABLE: CPI, YEAR 2029

Distribution of Changes to Mini Scenario Baseline Variable: CPI, Year 2029

Section 10: Concluding Comments

The pair of studies—RTD1 and RTD2—has produced forecasts for the four given economic variables, not only based on past trends but in consideration of future developments. The range of expectations was quite wide and generally reflected an inflationary future, largely determined by uncertain politics, disasters man-made and natural, and chance.

Methodologically, the pair of studies have illustrated several systematic techniques for forecasting the future value of time series variables by averaging estimates of individuals in a group; by combining extrapolative forecasts obtained through use of historical data and statistical curve fitting methods; and through combining group judgments about future developments that could deflect the extrapolations.

The study also demonstrated how the system could be used as a model of the future in policy analyses by simulating policy decisions through changing probabilities or impacts of postulated developments and observing the effects on the variables of interest.

Section 11: Acknowledgments

Appendix A: Participants

Table 14
THE RTD1 PARTICIPANTS

	Country	Expertise	Experience
1	United States	Futurist	More than 20 years' experience
2	United States	Actuary	More than 20 years' experience
3	Italy	Other (Statistician)	More than 20 years' experience
4	Canada	Actuary	More than 20 years' experience
5	Canada	Futurist	More than 20 years' experience
6	United States	Futurist	More than 20 years' experience
7	United States	Futurist	More than 20 years' experience
8	United States	Futurist	More than 20 years' experience
9	United States	Futurist	More than 20 years' experience
10	United States	Futurist	More than 20 years' experience
11	United States	Other	More than 20 years' experience
12	United States	Actuary	10-20 years' experience
13	Canada	Economist	5-10 years' experience
14	United States	Actuary	0-5 years' experience
15	United States	Actuary	10-20 years' experience
16	United States	Economist	More than 20 years' experience
17	United States	Futurist	More than 20 years' experience
18	United States	Actuary	More than 20 years' experience
19	Canada	Actuary	More than 20 years' experience
20	United States	Actuary	More than 20 years' experience
21	United States	Actuary	5-10 years' experience
22	Canada	Actuary	More than 20 years' experience
23	United States	Actuary	More than 20 years' experience
24	United States	Actuary	10-20 years' experience

Table 15
THE RTD2 PARTICIPANTS

	Country	Expertise	Experience
1	Israel	Actuary	More than 20 years' experience
2	United States	Actuary	5-10 years' experience
3	Canada	Futurist	More than 20 years' experience
4	United States	Scientist	More than 20 years' experience
5	Italy	Other	More than 20 years' experience
6	United States	Actuary	10-20 years' experience
7	Canada	Actuary	More than 20 years' experience
8	United States	Other	10-20 years' experience
9	Canada	Futurist	More than 20 years' experience
10	United States	Futurist	More than 20 years' experience
11	United States	Futurist	More than 20 years' experience
12	United States	Futurist	More than 20 years' experience
13	United States	Economist	More than 20 years' experience
14	United States	Actuary	5-10 years' experience
15	United States	Actuary	10-20 years' experience
16	United States	Actuary	More than 20 years' experience
17	United States	Actuary	More than 20 years' experience
18	United States	Futurist	More than 20 years' experience
19	United States	Actuary	More than 20 years' experience
20	United States	Actuary	More than 20 years' experience
21	United States	Actuary	More than 20 years' experience
22	Canada	Actuary	More than 20 years' experience
23	United States	Actuary	More than 20 years' experience
24	United States	Actuary	10-20 years' experience

Figure 11
RTD2, RTD1 TOTAL RESPONSES
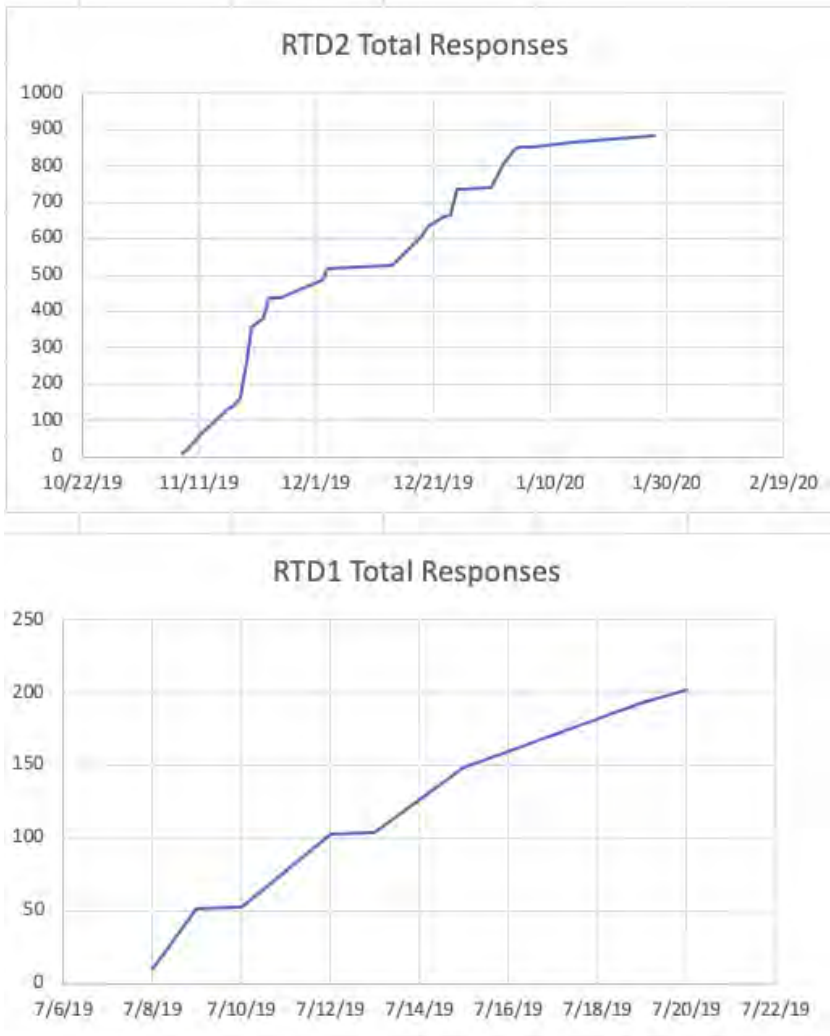
Figure 12

RTD2 NUMBER WHO SIGNED IN AND ANSWERED

Figure 13

RTD1 NUMBER WHO SIGNED IN AND ANSWERED

.

Appendix B: Questionnaires

B.1 RTD1

Figure 14
RTD1 QUESTIONNAIRE

RTD1 QUESTIONNAIRE CONTINUED

(1) High value: Representative of a 1 in 20 chance of occurrence at the end of each of the three respective Periods (i.e., right tail)

(2) Most likely value: The value of the variable you consider most likely at the end of each of the three respective Periods.

(3) Low value: Representative of a 1 in 20 chance of occurrence at the end of eac of the three respective Periods (i.e., left tail)

Thus there are 36 quantitative estimates requested: four variables at three time periods and at three levels of likelihood.

We are also interested in the reasoning you use in making these forecasts. You will note that the questionnaire provides a place for you to enter the rationales you used leading to your answers: what drivers/factors/developments/considerations influenced your responses? The place to enter this information is in the far right (long term) column but you may also enter rationales for the shorter and medium term.

The final two rows of the questionnaire request your views on catastrophic values and reversion to the mean for the variables.

Catastrophic values represent an improbable downside expectation with a 1 in 200 chance of occurrence at the end of the ten-year period. The values you provide should be absolute, not changes in values and recognize that for some variables either high of low values may denote catastrophic conditions. We also ask that you provide your rationales for your estimate, including, as applicable, why you view a low or high value to be catastrophic.

Mean Reversion is defined as the tendency of a variable to return to an average or long term trend after being disturbed. In the final question, for each of the four variables, we ask for your assumptions, inherent in your estimates for the three time periods of annual rate of mean reversion speed and duration in years until completion of reversion, and as in the other requests, we ask for your rationale including any personal biases you recognize (i.e. you tend to emphasize historical precedence.).

There are two ways to submit your quantitative answers. You can submit cell by cell by pressing the button marked "go" in each cell or by submitting the entire page of answers by pressing the "Submit this page" button at the bottom of the form. After you submit an answer in rows 1-4 (and at least two other responses have been recorded), two numbers will appear in parentheses: the group averages so far and the number of responses. It is also quite important for you to tell us about what rationales you used in making your quantitative judgments, by pressing the "click here" button in the third column in each row. This will take you to a new "rationales" page where your can enter a short narrative about your reasoning; please try to limit your response to less than 50 words. You can return to the questionnaire by closing the "rationales" window.

You may change any of your your previous answers at any time. You may also omit any questions you wish. If you leave at any point; when you return you will see your previous answers.

A second RTD will be conducted several weeks after completing the first RTD. Participants will be asked for their judgments of likelihood and impacts of future developments. The future developments will flow from rationales supplied by participants in this first RTD, with some additions by the study team. Participants will be asked to provide answers for both the future 10 years hence WITHOUT the event having occurred, and ten years hence WITH the event having occurred.

These responses will serve as inputs to a Trend Impact Analysis which will illustrate the cumulative effects of the developments on each variable through the use of a Monte Carlo model. This model will amend forecasts from this first RTD and be used to find the developments to which the forecasts are sensitive.
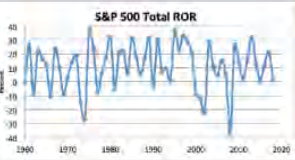
RTD1 QUESTIONNAIRE CONTINUED

Please return to the questionnaire often. When you return please enter as a returning participant and use this email address: actuary2 and this study code: SOA2 You will be able to change your answers and see the group responses as well.

Please remember to press SUBMIT at end of questionnaire.

Questionnaire

		Short term (2 years)	Medium term (5 years)	Long term (10 years)
Row 1 of 6	**Annual Changes in Consumer Price Index (YoY)** (details) 1980= 13.5% 2018=2.03% click here for example click here for example click here for example	Please enter your best estimate of the value of the variable ☐ High value ☐ Most likely ☐ Low value Submit only this cell [go]	Please enter your best estimate of the value of the variable ☐ High value ☐ Most likely ☐ Low value Submit only this cell [go]	Please enter your best estimate of the value of the variable ☐ High value ☐ Most likely ☐ Low value Submit only this cell [go] **Please provide rationales for your answers click here**

RTD1 QUESTIONNAIRE CONTINUED

| Row 2 of 6 | 10 Year US Treasury Yield (details) 1981=14.59% 2015=1.84% click here for example click here for example click here for example | Please enter your best estimate of the value of the variable ☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go | Please enter your best estimate of the value of the variable ☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go | Please enter your best estimate of the value of the variable ☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go **Please provide rationales for your answers click here** |
| Row 3 of 6 | S&P 500 Total ROR (details) 1997= 33.36 2008= -37.00 click here for example click here for example click here for example | Please enter your best estimate of the value of the variable ☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go | Please enter your best estimate of the value of the variable ☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go | Please enter your best estimate of the value of the variable ☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go **Please provide rationales for your answers click here** |

RTD1 QUESTIONNAIRE CONTINUED

		Please enter your best estimate of the value of the variable	Please enter your best estimate of the value of the variable	Please enter your best estimate of the value of the variable
Submit all rows Row 4 of 6	BAA Corporate Total Returns **Corporate Baa Spot Yields** (details) 1982= 17.10% 2017= 4.26% (est) click here for example click here for example click here for example	☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go	☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go	☐ **High value** ☐ **Most likely** ☐ **Low value** Submit only this cell go **Please provide rationales for your answers click here**
Row 5 of 6	**Consider catastrophic developments possible in the next 10 years** **Using the form accessed from the column to the right, what plausible values of the four variables would be considered catastrophic and when might they occur?** **Please enter the name of the variable and the high or low or both values that you think would indicate catastrophe and your judgment about timing. If you do not feel strongly on when the catastrophic event will occur in the 10-year Time Horizon, just add "na" to your answer.** **Examples:** **CPI (current= 2.5% BLS);** **Catastrophic: >+25% or <+1%; by 2022** **10 year treasuries (current 3.02% CNBC);** **Catastrophic: >+15% or <+1%;** **Timing: na** **S&P 500 total ROR (current= 9.5%);Catastrophic: <-40%** **Timing: 2021 or later** **Corp Baa (current= 5.22%);** **Catastrophic: >+18% or <+2.5%; na**	**To proceed to the answer form please click here**		

RTD1 QUESTIONNAIRE CONTINUED

	Reversion to the Mean	To proceed to the answer form please click here	
Row 6 of 6	Using the form to the right, please provide your assumptions inherent in your earlier answers Example: Assuming the current value of CPI is 3% and you think it will be 6% most likely in a reversion time of 15 years, the reversion speed would be (6-3)/15 or 0.2%/year. Your answer would appear: For CPI: Reversion time= 15 years Reversion speed= 0.2% per year. Together with rationales and recognized biases. And repeated for the other three variables.		

Submit this page

ADDITIONAL SUGGESTIONS

To submit comments and suggestions click here

To go to the top of this form click here

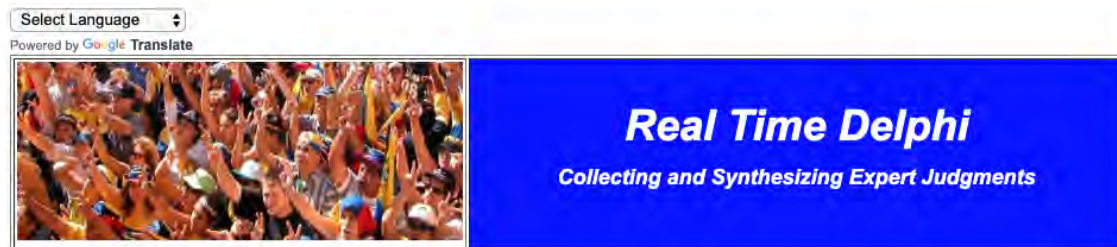To sign out click here

Date: 30 July, 2019

B.2 RTD2

Figure 15
RTD2 QUESTIONNAIRRE

Select Language ▾
Powered by Google Translate

Real Time Delphi
Collecting and Synthesizing Expert Judgments

Forecast of 4 Economic Variables

Making Estimations in Conditions of Uncertainty: An Exploration for the Society of Actuaries

To see the results of the first round click here

Please answer the questions in the form below. When you return please enter as a returning participant and use this email address: tedjgordon@gmail.com and this study code: SOA2A . This study is scheduled to close on 2019-11-22.

By pass introduction

This study follows one run several months ago that was designed to collect judgments about the future course of four economic variables:

1. Annual change in the Consumer Price Index
2. 10 Year Treasury Spot Par Yields
3. S&P 500 Total Annual Rate of Return (i.e. return inclusive of dividends)
4. Corporate Baa Spot Yields (for 10-year tenors)

In the process of the first RTD, we asked participants to provide rationales they considered in making their forecasts of the variables. Based on those inputs we compiled a list of 28 future developments that form the basis for this present questionnaire.

RTD2 QUESTIONNAIRRE CONTINUED

We ask for your judgments about the likelihood and timing and impacts of these developments. The "Likelihood" column asks for your judgment about the probability of the onset or occurrence of a development before 2030. If you think it will never happen, please enter a zero and go onto the next development. The "Year of Maximum Impact" column asks for your judgment about when the impacts of the development (as measured by these variables) might be greatest. The "Value of Maximum Impact" column asks for your estimates of the maximum impact of a development, were it to occur, on each variable.

There are two ways to submit your entries. First, cell-by-cell using the "Submit only this cell" button and second the whole page at once, using the "Submit this page" button at the bottom of the page and in some of the rows. Please be patient; it may take a few seconds for your input to be registered. In most instances two numbers will appear in parentheses after you have submitted your entries. These are the average so far and the number of responses including your own.

Also note, we are interested in your rationales; a special form can be accessed through the "click here" button in each cell.

You may omit any questions you wish and you do not have to complete this list of questions in one visit. When you return to the questionnaire you will see your previous answers and may add to them or change them if you wish. When you provide your inputs consider the rapid and deeply significant changes of the past decade (e.g. Brexit, the growth and power of social media, and changes in global trade policies); we probably will experience new developments of the same or even greater significance. Please return to the questionnaire often. When you return please use this email address: tedjgordon@gmail.com and this study code: SOA2A. Closing is expected on: 2019-11-22

Please return to the questionnaire often. When you return please enter as a returning participant and use this email address: tedjgordon@gmail.com and this study code: SOA2A .

Please remember to press SUBMIT at end of questionnaire.

RTD2 QUESTIONNAIRRE CONTINUED

Questionnaire

		Likelihood	Year of Maximum Impact	Value of Maximum Impact

Row 1 of 29	**US stabilizes its debt by monetizing all future deficits.**
	
	(details)
	
	click here for reference
	
	click here for reference
		What is the percentage likelihood of the onset or occurrence of this development before 2030?
		
		0 %
		
		Changes are
		OK
		
		Submit only this cell go
		
		To provide the rationale for your answer *click here*
			In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.
			
			[ ]
			
			Submit only this cell go
			
			To provide the rationale for your answer *click here*
				How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter –.5.
				
				  CPI%(YoY)
				
				  10 Year Treasury Yield %
				
				  S&P 500 Total Return %
				
				  Corporate Baa Spot Yields %
				
				Submit only this cell go
				
				To provide the rationale for your answer *click here*

Row 2 of 29	**The US Federal Reserve is controlled by the executive branch** (details) *click here for reference* *click here for reference*	What is the percentage likelihood of the onset or occurrence of this development before 2030? 10 % Changes are avg= 3.33 (3) OK *Submit only this cell* go **To provide the rationale for your answer** *click here*	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen. 2022 Changes are OK avg= 2,022.0 (1) *Submit only this cell* go **To provide the rationale for your answer** *click here*	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter –.5. -.2 **CPI%(YoY) (-0.2) (1)** -1 **10 Year Treasury Yield % (-1.0) (1)** -1 **S&P 500 Total Return % (-1.0) (1)** -1 **Corporate Baa Spot Yields % (-1.0) (1)** *Submit only this cell* go **To provide the rationale for your answer** *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Submit all rows Row 3 of 29	*US defaults on its debt or pegs US dollar to gold at $10,000 level* *(details)* *click here for reference* *click here for reference*	0 % Changes are OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	**Submit only this cell** go **To provide the rationale for your answer** *click here*	_____ **CPI%(YoY)** _____ **10 Year Treasury Yield %** _____ **S&P 500 Total Return %** _____ **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** *click here*
Row 4 of 29	*Amount of debt with negative interest rates (as percentage of all debt) reaches 33%* *(details)* *click here for reference* *click here for reference*	What is the percentage likelihood of the onset or occurrence of this development before 2030? 0 % Changes are OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen. _____ **Submit only this cell** go **To provide the rationale for your answer** *click here*	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5. _____ **CPI%(YoY)** _____ **10 Year Treasury Yield %** _____ **S&P 500 Total Return %** _____ **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 5 of 29	**US economy enters a period that economists call a "liquidity trap."** *(details)* *click here for reference* *click here for reference*	___ % **Submit only this cell** go **To provide the rationale for your answer** *click here*	**Submit only this cell** go **To provide the rationale for your answer** *click here*	___ **CPI%(YoY)** ___ **10 Year Treasury Yield %** ___ **S&P 500 Total Return %** ___ **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** *click here*
Submit all rows Row 6 of 29	**US economy enters a period that economists call stagflation** *(details)* *click here for reference* *click here for reference*	2 % Changes are avg= 19.00 (3) OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	2026 Changes are OK avg= 2,023.7 (3) **Submit only this cell** go **To provide the rationale for your answer** *click here*	-1 **CPI%(YoY) (3.5) (2)** -1 **10 Year Treasury Yield % (-0.5) (2)** -2 **S&P 500 Total Return % (-1.0) (2)** -4 **Corporate Baa Spot Yields % (-2.0) (2)** **Submit only this cell** go **To provide the rationale for your answer** *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Submit all rows Row 6 of 29	US economy enters a period that economists call stagflation (details) click here for reference click here for reference	2 % Changes are OK avg= 19.00 (3) Submit only this cell go To provide the rationale for your answer click here	2026 Changes are OK avg= 2,023.7 (3) Submit only this cell go To provide the rationale for your answer click here	-1 CPI%(YoY) (3.5) (2) -1 10 Year Treasury Yield % (-0.5) (2) -2 S&P 500 Total Return % (-1.0) (2) -4 Corporate Baa Spot Yields % (-2.0) (2) Submit only this cell go To provide the rationale for your answer click here
Row 7 of 29	Guaranteed minimum income established in US and most other OECD countries at 25% above poverty level. (details) click here for reference click here for reference	5 % Changes are OK avg= 17.50 (2) Submit only this cell go To provide the rationale for your answer click here	2025 Changes are OK avg= 2,025.0 (2) Submit only this cell go To provide the rationale for your answer click here	1.5 CPI%(YoY) (1.5) (1) -.5 10 Year Treasury Yield % (-0.5) (1) -1 S&P 500 Total Return % (-1.0) (1) -1 Corporate Baa Spot Yields % (-1.0) (1) Submit only this cell go To provide the rationale for your answer click here

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 8 of 29	*Federal debt to GDP ratio reaches 150%.* *(details)* *click here for reference* *click here for reference*	____ % **Submit only this cell** go **To provide the rationale for your answer** *click here*	2040 Changes are OK avg= 2,032.5 (2) **Submit only this cell** go **To provide the rationale for your answer** *click here*	**CPI%(YoY)** **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** *click here*
Submit all rows Row 9 of 29	*Federal debt to GDP ratio reaches 50%.* *(details)* *click here for reference* *click here for reference*	____ % **Submit only this cell** go **To provide the rationale for your answer** *click here*	____ **Submit only this cell** go **To provide the rationale for your answer** *click here*	**CPI%(YoY)** **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 10 of 29	**US taxation increased to a level that balances the budget** *(details)* click here for reference click here for reference	0 % **Changes are OK** **Submit only this cell** go **To provide the rationale for your answer** click here	**Submit only this cell** go **To provide the rationale for your answer** click here	CPI%(YoY) **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** click here
Row 11 of 29	**Carbon tax is implemented worldwide** *(details)* click here for reference click here for reference	3 % **Changes are OK** avg= 36.50 (2) **Submit only this cell** go **To provide the rationale for your answer** click here	2040 **Changes are OK** avg= 2,031.5 (2) **Submit only this cell** go **To provide the rationale for your answer** click here	3 CPI%(YoY) (3.0) (1) 3 **10 Year Treasury Yield %** (3.0) (1) 1 **S&P 500 Total Return %** (1.0) (1) 3 **Corporate Baa Spot Yields %** (3.0) (1) **Submit only this cell** go **To provide the rationale for your answer** click here

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Submit all rows Row 12 of 29	*EU fails and countries/currencies regain independence* *(details)* *click here for reference* *click here for reference*	5 % **Changes are OK** avg= 7.50 (2) *Submit only this cell* go *To provide the rationale for your answer click here*	2025 Changes are OK avg= 2,025.0 (1) *Submit only this cell* go *To provide the rationale for your answer click here*	3 **CPI%(YoY) (3.0) (1)** 0 **10 Year Treasury Yield % (0.0) (1)** 2 **S&P 500 Total Return % (2.0) (1)** 2 **Corporate Baa Spot Yields % (2.0) (1)** *Submit only this cell* go *To provide the rationale for your answer click here*
Row 13 of 29	*US adopts single-payer health care* *(details)* *click here for reference* *click here for reference*	50 % **Changes are OK** avg= 30.00 (2) *Submit only this cell* go *To provide the rationale for your answer click here*	2025 Changes are OK avg= 2,022.5 (2) *Submit only this cell* go *To provide the rationale for your answer click here*	2 **CPI%(YoY) (2.0) (1)** 2 **10 Year Treasury Yield % (2.0) (1)** 1 **S&P 500 Total Return % (1.0) (1)** 3 **Corporate Baa Spot Yields % (3.0) (1)** *Submit only this cell* go *To provide the rationale for your answer click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 14 of 29	**Wealth inequality - The dozen countries with the highest current wealth gap between richest and poorest people enact political and economic reforms designed to close the gap within 3 years.** *(details)* click here for reference click here for reference	10 % **Changes are OK** avg= 40.00 (2) **Submit only this cell** go **To provide the rationale for your answer click here**	2030 Changes are OK avg= 2,025.0 (2) **Submit only this cell** go **To provide the rationale for your answer click here**	2 **CPI%(YoY) (2.0) (1)** 1 **10 Year Treasury Yield % (1.0) (1)** 1 **S&P 500 Total Return % (1.0) (1)** -1 **Corporate Baa Spot Yields % (-1.0) (1)** **Submit only this cell** go **To provide the rationale for your answer click here**
Submit all rows Row 15 of 29	**National elections in the US become chaotic to the extent that violence often erupts quelled by armed force.** *(details)* click here for reference click here for reference	35 % **Changes are OK** avg= 32.50 (2) **Submit only this cell** go **To provide the rationale for your answer click here**	2024 Changes are OK avg= 2,022.0 (2) **Submit only this cell** go **To provide the rationale for your answer click here**	4 **CPI%(YoY) (4.0) (1)** -2 **10 Year Treasury Yield % (-2.0) (1)** -2 **S&P 500 Total Return % (-2.0) (1)** -3 **Corporate Baa Spot Yields % (-3.0) (1)** **Submit only this cell** go **To provide the rationale for your answer click here**

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030? ___ %	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen. ___	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 16 of 29	**Trade tariffs and currency wars double in number and size in relation to 2019 levels.** *(details)*	*Submit only this cell* go *To provide the rationale for your answer* *click here*	*Submit only this cell* go *To provide the rationale for your answer* *click here*	*CPI%(YoY)* ___ *10 Year Treasury Yield %* ___ *S&P 500 Total Return %* ___ *Corporate Baa Spot Yields %* ___ *Submit only this cell* go *To provide the rationale for your answer* *click here*
Row 17 of 29	**Tariff and trade wars are resolved** *(details)* *click here for reference* *click here for reference*	What is the percentage likelihood of the onset or occurrence of this development before 2030? ___ % *Submit only this cell* go *To provide the rationale for your answer* *click here*	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen. ___ *Submit only this cell* go *To provide the rationale for your answer* *click here*	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5. *CPI%(YoY)* ___ *10 Year Treasury Yield %* ___ *S&P 500 Total Return %* ___ *Corporate Baa Spot Yields %* ___ *Submit only this cell* go *To provide the rationale for your answer* *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.

Submit all rows
Row 18 of 29
	US armed conflict with one or more major nations, involving more than 50,000 US troops.
	
	(details)
	
	click here for reference
	
	click here for reference
		50 %
		
		Changes are avg= 50.00 (2)
		OK
		
		Submit only this cell go
		
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			To provide the rationale for your answer click here
				CPI%(YoY)
				
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				   S&P 500 Total Return %
				
				   Corporate Baa Spot Yields %
				
				Submit only this cell go
				
				To provide the rationale for your answer click here

Row 19 of 29	*Incumbent loses reelection in 2020: US policies revert to former era.* *(details)* *click here for reference* *click here for reference*	55 % Changes are avg= 62.50 (2) OK *Submit only this cell* go *To provide the rationale for your answer click here*	2023 Changes are OK avg= 2,021.5 (2) *Submit only this cell* go *To provide the rationale for your answer click here*	1 **CPI%(YoY) (1.0) (1)** 1 **10 Year Treasury Yield % (1.0) (1)** 1 **S&P 500 Total Return % (1.0) (1)** 1 **Corporate Baa Spot Yields % (1.0) (1)** *Submit only this cell* go *To provide the rationale for your answer click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 20 of 29	**Major hack cripples the financial system for one month; 50% of individual depositors and corporations cannot reconstruct the amounts in their accounts; stock trades must be documented by hand.** *(details)* *click here for reference* *click here for reference*	5 % Changes are avg= 7.50 (2) OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	2030 Changes are OK avg= 2,030.0 (1) **Submit only this cell** go **To provide the rationale for your answer** *click here*	3 **CPI%(YoY) (3.0) (1)** -2 **10 Year Treasury Yield % (-2.0) (1)** -2 **S&P 500 Total Return % (-2.0) (1)** -2 **Corporate Baa Spot Yields % (-2.0) (1)** **Submit only this cell** go **To provide the rationale for your answer** *click here*
Submit all rows Row 21 of 29	**Rapid growth of the use of robotics and artificial intelligence in major economies worldwide; machines take over 1/3 of today's jobs.** *(details)* *click here for reference* *click here for reference*	85 % Changes are avg= 57.50 (2) OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	2040 Changes are OK avg= 2,035.0 (2) **Submit only this cell** go **To provide the rationale for your answer** *click here*	1 **CPI%(YoY) (1.0) (1)** 1 **10 Year Treasury Yield % (1.0) (1)** 3 **S&P 500 Total Return % (3.0) (1)** 5 **Corporate Baa Spot Yields % (5.0) (1)** **Submit only this cell** go **To provide the rationale for your answer** *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter –.5.
Row 22 of 29	*Price of oil drops below $30 for more than a year* *(details)* click here for reference click here for reference	2 % Changes are avg= 6.00 (2) OK **Submit only this cell** go **To provide the rationale for your answer** click here	**Submit only this cell** go **To provide the rationale for your answer** click here	CPI%(YoY) **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** click here
Row 23 of 29	**Climate change remediation programs prove to be ineffective: food prices rise 20%** *(details)* click here for reference click here for reference	5 % Changes are avg= 37.50 (2) OK **Submit only this cell** go **To provide the rationale for your answer** click here	**Submit only this cell** go **To provide the rationale for your answer** click here	CPI%(YoY) **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** click here

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter –.5.
Submit all rows Row 24 of 29	**Perceived life expectancy at birth in the US increases to 90 years** *(details)* *click here for reference* *click here for reference*	25 % Changes are avg= 27.50 (2) OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	 **Submit only this cell** go **To provide the rationale for your answer** *click here*	____ **CPI%(YoY)** ____ **10 Year Treasury Yield %** ____ **S&P 500 Total Return %** ____ **Corporate Baa Spot Yields %** **Submit only this cell** go **To provide the rationale for your answer** *click here*
Row 25 of 29	**Pandemic kills 1% of world population (Spanish flu of 1918 is estimated to have killed between 50 and 100 million people worldwide)** *(details)* *click here for reference* *click here for reference*	.5 % Changes are avg= 15.25 (2) OK **Submit only this cell** go **To provide the rationale for your answer** *click here*	2035 Changes are OK avg= 2,035.0 (1) **Submit only this cell** go **To provide the rationale for your answer** *click here*	3 **CPI%(YoY) (3.0) (1)** -2 **10 Year Treasury Yield % (-2.0) (1)** -2 **S&P 500 Total Return % (-2.0) (1)** -2 **Corporate Baa Spot Yields % (-2.0) (1)** **Submit only this cell** go **To provide the rationale for your answer** *click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 26 of 29	*Natural disaster kills 100,000 in US (e.g. earthquake in LA or Puget Sound)* *(details)* *click here for reference* *click here for reference*	0 % **Changes are OK** *Submit only this cell* go *To provide the rationale for your answer click here*	*Submit only this cell* go *To provide the rationale for your answer click here*	CPI%(YoY) **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** *Submit only this cell* go *To provide the rationale for your answer click here*
Submit all rows Row 27 of 29	*Massive terror attack kills more than 10,000 people in the US.* *(details)* *click here for reference* *click here for reference*	4 % **Changes are** avg= 17.00 (2) **OK** *Submit only this cell* go *To provide the rationale for your answer click here*	2035 **Changes are OK** avg= 2,035.0 (1) *Submit only this cell* go *To provide the rationale for your answer click here*	CPI%(YoY) **10 Year Treasury Yield %** **S&P 500 Total Return %** **Corporate Baa Spot Yields %** *Submit only this cell* go *To provide the rationale for your answer click here*

RTD2 QUESTIONNAIRRE CONTINUED

		What is the percentage likelihood of the onset or occurrence of this development before 2030?	In what year do you believe the development will have its maximum impact on the variables? Leave blank if you think it will never happen.	How much would the variable change in the year of maximum impact? Example: if the variable had a value of 5% without the development and 4.5% with the development, enter -.5.
Row 28 of 29	*Space travel becomes economical for 10% of US citizens* *(details)* **click here for reference** **click here for reference**	0 % Changes are OK **Submit only this cell** go *To provide the rationale for your answer click here*	**Submit only this cell** go *To provide the rationale for your answer click here*	*CPI%(YoY)* *10 Year Treasury Yield %* *S&P 500 Total Return %* *Corporate Baa Spot Yields %* **Submit only this cell** go *To provide the rationale for your answer click here*
Row 29 of 29	*Other developments that you think we should consider?*	*To proceed to the answer form please click here*		

Submit this page

ADDITIONAL SUGGESTIONS

To submit comments and suggestions click here

Please remember to return to the questionnaire often. When you come back, you will see how the group's answers have evolved and can edit your comments in response. If you have difficulties please send your questions to realtimedelphi@gmail.com .

Appendix C: Qualitative Responses, Rationales

This appendix contains responses of participants as they were submitted (lightly edited to correct spelling errors, etc.) There are three sections in this appendix rationales offered for the quantitative submissions pertinent to the forecasts of the four variables (RTD1), raw responses to the open-ended question about additional developments, and rationales behind the responses to RTD2.

C.1 RATIONALES BEHIND RESPONSES IN RTD1

Responses to Question 1.
Annual Changes in Consumer Price Index (YoY)

1. I have assumed that the U.S. Federal Reserve manages interest rates to keep things "under control"; their target is apparently 2%, but their ability to move to and hold this rate is highly uncertain. I think thieves may hack into the financial funds transfer system and cause massive chaos; loss could be billions.

2. Too much liquidity will lead to inflation which cannot be contained.

3. I have assumed that the Fed is unable to control inflation. Inflation is what it is, and monetary policy has little influence. I believe that inflation hasn't grown as much, because in the digital age companies become more efficient in production and will keep cost of production low, keeping inflation low. But for the high end, it could creep up much higher. Deflation seems unlikely.

4. A combination of elements outside the control of the Fed are likely to increase CPI beyond what we can foresee today. Increasing consumerism globally as a result of growing middle class in emerging economies (e.g., China) will most likely lead to rising prices in North America for many products. Food prices are expected to rise considerably, given the combination of increasing demand (growing population with increasing purchase power), the impacts of climate change that will reduce production scale, and the increasing reliance on local sources. These will impact all the other prices. Monopoly combined with increasing demand for rare earth elements/materials (or rare anything) while they become less available given climate change will impact prices for high-tech and renewables.

5. My responses combine a Rogoff/Reinhart This Time is Different argument as the signal and assume that monetary policy is only noise when debt to GDP ratios are above 100%. I think that the effect will be triggered in the next few years, leading to short-term stagflation, and start cycling back to normal by 10 years out. Farther out demographics will drive deflation.

6. Inflation pressures will build up but only marginally and temporarily. In the medium term, the impact of massive debt builds up as a consequence of central bank policy of "borrow to front end consumption even though you can't really afford it" will be felt. However, among the unknowns are what new tricks central bankers will come up with, which could spike inflation, such as the U.S. Treasury issues a $25 trillion-plus bond to the Fed to monetize its debt. In the long term, there is even more uncertainty stemming from the unknown impact of AI on jobs—at the extremes (i) deflation due to massive unemployment; (ii) high inflation from high success in worker transition to the new economy; and also spending habits of the increasing number of retirees who are increasingly under funding their retirements

7. A combination of mean reversion (Fed's target and monetary policy) and monetary supply/demand imbalances (deflation vs. inflation) that cause the variation/uncertainty

8. In the short-term, food prices driven by trade tariffs will push up the index while demand for consumer goods remains stable pending U.S. election. In the period following the election, the mid-term will see

increase in demand for consumer goods driven by technological obsolescence coupled with continuing lack of international agreement on trade regulations driving up prices. The longer term depends a great deal on the developing economies in Africa and South Asia. They could well become strong enough to influence increase global demand driving up prices or, less likely in 10 years, reducing prices by increasing supply of both food and consumer goods.

9. Central expectation is that Fed holds and maintains the 2% target. Risks are skewed evenly up/down. Up risk is inflation from rising debt ratios. Down risk is Japan-like low growth risk, with massive quantitative easing.

10. Based on historical patterns, where bounds are based on moving averages in the short term and a regime-changing model in medium and long terms (i.e., 1 in 20 chance a recession environment similar to late 2000s or boom environments in earlier decades will occur and the lowest/highest inflation rates during those regimes.) Most likely assumes that mild or moderate growth continues due to Fed control actions and offsetting trends in work and production environments.

11. Given the cooling of the economy, I think that in the coming years a rise will be possible but it will also be very slow. The effects of the global crisis will last for several more years.

12. Despite the protracted period of low and stable prices, politics (including especially trade disputes), environmental changes and income disparities in the U.S. make the next 10 years highly uncertain. In the near term, there is more negative pressure on interest, but in the longer term there is the possibility of strong upward pressure. This is especially magnified by global weather trends and their impact on food and transportation.

13. Trade war in the short term, a series of QEs in the medium/long run will bring up to historic level and beyond.

14. There are inflationary pressures already in the economy. These could become apparent in the short term and even be energized by an unwise rate cut. Medium term, the Fed will stick to its 2.0% inflation target and can realize that over a five-year period. I discount the experience of the 1970s and 1980s, but deficit spending and conflict with China could push inflation for a few years. Long term, I think that the same factors as medium term apply. The Fed will ultimately hold the line on inflation.

15. See deflation as a dominant trend, but probably one "last gap" in the medium term to pump it up.

16. Fed will continue to keep interest rates low to try to keep the economy growing, putting upward pressure on inflation. This will be partially offset by offshoring and other efficiency options. Crap shoot as to which factor will dominate.

17. Fed has the mandate and tools to prevent a sustained period of deflation—very unlikely to see CPI below 1.5% in the short term. Could be worse longer term due to unpredicted scenarios, but deflation is unlikely. Also, very high inflation is unlikely with aging populations and limited economic growth and new demand.

Rationales for responses to Question 2.
10-year U.S. Treasury Yield

18. I assume the return will be slightly higher than CPI; volatility in CPI means volatility here; the Fed's inability to hold CPI rates will be reflected here too.

19. Inflation will be mounting.

20. The 10-year is volatile, and I have been watching it daily over the past five years. Our asset management team is consistently wrong at predicting this number. I assume that it will likely go up in the short term to 2.5% but will mean revert higher to 3.5%. However, in five to 10 years, this likely could trend higher. Given what other countries are going through, seeing it below 1% at some point would not be outrageous.

21. High debt to GDP ratio leads to higher Treasury yields to account for higher risk. Could see demographic trends to low/negative yields over longer periods. Currently seeing junk bonds at negative nominal rates in Europe, so not impossible.

22. In relation to CPI, have added real rate assumptions 100bps,−100bps and 0 respectively for the short, medium and long term most likely. For high value and low value, added/subtracted 100bps to the most likely.

23. Short-term view (2-year) Current interest rate (with a slight drift to an ultimate level) + possible change in interest rate given a 2-year time horizon (similar to Value at Risk calculation assuming a normal distribution) Long-term view (5-, 10-year) Mean reversion to a possible equilibrium state (inflation level + real economic growth + risk premium) Uncertainty around the mean reversion level using historical data

24. Treasury yields will follow patterns of inflation rates except at high and low moves away from median.

25. Base case is inflation plus average GDP growth.

26. From the time series, it seems that we have just passed a minimum and that, therefore, in the future the growth will be quite probable. But even in this case, we cannot expect a high growth rate, like that of the 1970s.

27. Low inflation will force short-term interest rates to stay low. Extremely strong demand for safe product will continue to drive the maturity premium lower. Foreign demand for U.S. assets will pressure down U.S. yields. Both result in 10-year yields unable to breach above the local maximum reached in 2018. Debt and fiscal risk will not be a concern incorporated in the Treasury market.

28. So much depends on how integrated the U.S. is in the world economy. In 2019, the U.S. has been working to weaken the bonds of globalization. In the near-term, other countries have limited ability to dump U.S. treasury bonds because they need $-denominated alternatives. But as treasuries mature, current holders will have more flexibility, especially if the U.S. share diminishes. This would drive treasury interest up. If, however, the U.S. reassert its global leadership, interest may stay low.

29. There is clearly a reverting momentum reverting back to higher level, higher than CPI but not as high as historic average. I also have a belief that artificial intervention will be more rational and frequent than last century.

30. In the short term, the 10-year rate will track inflation. My estimates for the 10-year mimic my assessments for inflation. Similar in the medium term, allowing for some additional risk aversion (aka term premium). Since I think the Fed will contain inflation, my long-term estimates are based on adding a bit more noise to inflation movements but not term premia.

31. Same general rationale as for interest rates

Rationales for Responses to Question 3.
S&P 500 Total ROR

32. Who knows; very high uncertainty. Depends on trade tariffs, U.S. election results, new and unheard-of inventions, consumer preferences, wars and saber-rattling.

33. Inflation mounting with stock returns going negative

34. S&P on average returns 8%. The best two-year growth ever was 45%, implying 22% YoY return. The negative growth is based more on hunch than anything in this first go-around.

35. Consistently loose fiscal and monetary policy will need to reset, and reduced trade/increased tensions could trigger at least recession soon. Trade tensions, twitter rants, election uncertainty and reduced earnings could also lead to tipping point for investor sentiment.

36. Equity returns have been massively distorted in relation to steady state growth rates by central bank facilitated financial engineering. Sharp correction in two years, followed by improving path.

37. I could see catastrophic events tripping up the stock market. I could also see investor sentiment becoming a problem at some point. For now, I think the odds of a recession are very low. I think the earnings for corporations will remain strong. I also think the tariff and trade wars will be resolved during the coming election year. Longer term, I expect increases in taxes and pressure on corporate earnings due to competition globally. I also see the costs of addressing climate change and other social pressures coming to bear on corporate profits.

38. Expected annualized total return level is developed based on the equilibrium interest rate level (which implicitly includes the inflation/real GDP growth) plus equity risk premium (or market risk premium). The uncertainty around the expected level is based on the historical analysis of annualized total return.

39. Returns entered as compound annual returns. Base case is approximately 400bp over the average 10-year Treasury.

40. Market is stable over first few years and most likely reaches historical stability by 10 years. T Possibility for extreme events given labor trends and political environment.

41. Looking at the time series, it is clear that this variable is highly variable over the years. This means that going forward in time, the fork between minimum and maximum must necessarily increase, around an average value that is able to be around 5.

42. Short-term returns will be held back by trade war, and slowing economic growth. Medium- and long-term returns will be driven by rate of nominal GDP growth. But there is no limit to what valuation can reach, so medium- and long-term returns incorporate a valuation premium always growing.

43. A cyclic pattern can be easily observed. Expect the trend to continue unless disturbed by random/surprising events trade war, election, war, etc.

44. In the short term, the equity market looks pricey, especially now that we are long in the tooth in the expansion. Rate cuts will make the matter more unstable. Medium-term normal historical ranges should apply and long term the same with a bit more noise.

45. Very high volume market right now. Trump tax cuts and regulatory cutbacks are generally business friendly. But trade wars and economic collapse could drive things the other way.

46. Median or most likely is based on expectation of market risk premium (with market risk premium increasing slightly over time). Range of values are hard to predict, but expect the range of values to be tilted slightly negative with more downside risk than upside.

Rationales for Responses to Question 4.
Corporate Baa Spot Yields

47. Have some U.S. manufacturers returned to the U.S.? Has Trump been re-elected? Is China flourishing? Brexit may fail, and this could echo in U.S. Baa returns.

48. Inflation.

49. The trend downward since 1990 is concerning. It would take a stock market drop to increase the cost of borrowing.

50. Spreads on Baa bonds will widen, along with Treasury yields, as recession occurs. Non-independent Fed could lose control of rates as bailouts are no longer available and the 30-year trend is reversed and accountability returns.

51. With respect to Treasuries I have added spread assumptions 400bps, 300bps and 200bps, respectively, for the short, medium and long term, consistent with view of pain two years from now, and with linear tightening of spreads thereafter.

52. Expected level risk-free interest rate plus expected credit spreads, uncertainty is based on the historical Baa yield over each time horizon (e.g., two, five and 10 years) .

53. Small increases in spreads over time widens range of possible values consistent with patterns for other variables.

54. The trend of the time series is strongly correlated to that of the second variable. Therefore, from a purely statistical point of view, a possible forecast will follow the same logic.

55. Corporate bond returns made of long-term risk-free rate and credit risk premium. Historical average risk premium assumed to become tighter as demand for yields move beyond Treasury due to low interest rates globally.

56. Black swan events, although can make sudden turns, are excluded as they could never be predicted. So in general, short, medium and long terms tends to follow best estimate pattern and gradually flare up in a compounding manner. The rate is supported by risk-free rate, thus can hardly fall below 2%.

57. BBB yields will track 10-year treasury plus spread. Highest values will happen in a crisis. Low will happen when Treasury is low and investors are reaching for yield.

58. Roughly maintaining spreads over treasuries.

59. Credit spreads will stay tight for the next two years but widen after that as concerns about credit exposure increase. Low value would require very low inflation and a very soft impact from end of credit cycle. If credit cycle end is more difficult, high value will go back to the values experienced in 2008.

C.2 DEVELOPMENTS SUGGESTED IN RTD1

84. This is a suggestion from the questionnaire:

Comments: What developments that can affect the variables? Artificial general intelligence happening faster than expected, like in five to 10 years; much more rapid adoption of high-performance 3D printers in community centers able to substitute previous purchases; and high-performance 3D printers affecting international trade. Synthetic biology creating micro-organisms able to affect plaque in the brain, making older people more productive as longevity research produces new therapies for longer life.

86. This is a suggestion from the questionnaire:

Comments: Other market swinging developments 1) massive terror attack killing upwards of 10,000; 2) North Korea explodes another nuclear weapon; 3) U.S. and Iran at war; 4) world fertility rates drop below replacement; 5) Democrats take U.S. White House, Senate and House of Representatives in 2020; 6) U.S. adopts single-payer health care; 7) 35% of all corporate assets that went overseas for low labor costs have returned to the U.S. homeland; 8) flow of legal and illegal immigration into U.S. drops by 30%; 9) U.S. annual deficit (intake minus expenditures) drops by 50% for three years in a row.

C.3 RATIONALES BEHIND RESPONSES IN RTD2

Question 1. US stabilizes its debt by monetizing all future deficits.

1. Requires too much radical coordination among political and financial market participants. Ignores large amounts of debt held overseas.

2. 105% debt to GDP has few solutions—this may be viewed by politicians as the easy way out.

3. Seems very unlikely to me no matter who is Pres.

4. It is easier to monetize than to make difficult political choices. Since dealing with the deficit will be forced on the federal government, it is natural to take the path of least resistance.

5. Given the inflation is not a big risk, monetizing the debt could be considered as an option.

6. Not in the foreseeable future or in the BAU scenario.

7. Ted to a war against China/India/Iran/Russia.

8. Never (or at least after 2040).

9. Loss of confidence in U.S.

10. Key is velocity of money—when it spikes due to loss of confidence, all bets are off. I believe this is likely whether MMT is implemented or not.

11 Very hard to estimate. All bond yields will elevate, and eventually equities will tend to hedge inflation. Initially, there will be broad market disruptions.

12. Destabilizing for global markets. Loss of confidence in USD as safe harbor currency. Quite negative for all capital markets ... de-risking is significant. Gold price shoots up.

Question: 2. The U.S. Federal Reserve is controlled by the executive branch.

13. There is a small undercurrent of "Audit the Fed" from libertarians and Rand Paul. I sense there is apprehension about government-owned banking.

14. If Trump wins in 2020, he will certainly try to make this happen, as he has already demonstrated.

15. Trump has achieved some degree of capture already; this may be orchestrated globally.

16. It might happen by necessity, if there will be too much financial chaos nationally or internationally.

17. I have assumed Trump gets re-elected. And then continues his unrelenting pressure on the Fed.

18. An international financial chaos triggered or increased by Chinese growing power, mismanagement of the European Central Bank and a fast devaluation of the USD might ask for very drastic measures.

19. Half way through next presidential cycle.

20. I assume this could only happen if the Republicans win in 2020. If so, Trump will try to drive down interest rates, so I answered this question with that in mind.

21. Assumes Republicans win in 2020.

Question: 3. U.S. defaults on its debt or pegs U.S. dollar to gold at $10,000 level.

22. Default can come in a variety of ways other than outright refusal to pay. More likely to freeze interest rate payments than refuse to pay. I do not see why you have tied default to a gold peg. Do not see a gold peg in the future. Fiat money is the cornerstone of flexible, if sometimes questionable, monetary policy.

23. Printing money is too easy.

24. The Fed and Treasury will do everything possible to prevent default. On the other hand, pegging to gold might be a strategy if inflation gets out of hand.

25. Will eventually cycle back to the gold standard, but disaster must strike first.

26. If U.S. debt continues to grow uncontrolled, and Trump gets reelected, and the U.S. Federal Reserve gets controlled by the executive branch, at some point, there might be an executive decision of default on its debt.

27. May be selective default to only foreign borrowers—likely requires war as driver.

28. I did not answer because of the very low probability of this development.

29. I did not answer because of the very low probability of this development.

30. Bretton Woods conference would follow next global war and a return to the gold standard.

31. Post-default debt gets revalued under the new regime most likely in a surprisingly orderly fashion. The key thing is to establish credibility and a set of guidelines that are tradeable and can be used for planning. We have seen this again and again in South America. We might even see interest rates fall if the new regime is viewed as sustainable. Equity market will eventually thrive if the new regime is sustainable and credible.

Question: 4. Amount of debt with negative interest rates (as percentage of all debt) reaches 33%.

32. The borrowing economy is not permanently sustainable. And Fed has shown some past signals that it is willing to raise rates.

33. For the U.S. to issue debt with interest rates lower than actual or anticipated inflation would require a situation involving a sudden spike in inflation (e.g., war, virtual failure of financial system, etc.) or the rise of interest rates in a foreign country with stable economics and prospects that gives the U.S. paper competition.

34. The continuous high-rate growth of the Chinese political and financial power and its influence in more and more countries around the world and over financial institutions might have a huge impact on the (in)stability of the international financial system.

35. Low growth will keep rates low or negative—may have hyperinflation spurt, but demographics says rates go down.

36. Presumably, this question refers to U.S. debt only. Since we have no negative yielding U.S. debt today, a jump to 33% is quite a lot. However, if we have a major decline in GDP growth and the left wing controlling the executive and Congress, then this is probable.

37. End of next presidential cycle—change of party.

38. Once negative debt starts, it will take a decade or more to run out. End date offered is 2030, so I choose the maximum date even though I expect the effect to worsen beyond that date if it gets started.

39. Driven by low growth, so low CPI and low equity returns with higher defaults.

40. Difficult to estimate. Directionally, bond yields and inflation decline and equity returns are repressed. [Not sure why average changes are showing up positive here—program error or respondent misunderstanding?]

41. Continuation of current global trend. Global growth continues to trend lower. Central banks trying to stimulate growth are somewhat unsuccessful. US markets trend in line with global trends, but not catastrophic.

Question: 5. U.S. economy enters a period that economists call a "liquidity trap."

42. Some possibility for stagnation and the mortality/fertility balance seems to follow the Japan path. Too many other potential shocks to lock in with any strong certainty.

43. 2008 did not improve transparency enough, and now shadow banks are picking up the banking slack with even less transparency.

44. Arguably, we are already there.

45. No signs of lowering debt to GDP—seems inevitable, just waiting for a triggering event.

46. The circumstance seem improbable.

47. Not likely.

48. No guns left in the monetary policy gun, so likely will last many years.

49. Depends on multiple impacts/scenarios hitting at the same time. Central banks trying to support liquidity but cannot reverse trend ... markets decide to run for the hills. Riskier assets all become illiquid.

Question: 6. U.S. economy enters a period that economists call stagflation.

50. High debt, combined with QE could easily end up with stagflation scenario.

51. This would be a bifurcation from where we are now, but it does not take much to force a revision of expectations, and it is a widespread expectation of persistent inflation that leads to stagflation. If a change in fiscal policy caused a loss of faith in savings vehicles and accelerated inflation, that would be a catalyst.

52. After the 2024 election.

53. After 2024—new party spends, trigger event like Middle Eastern war leads to high VM.

54. Crazy scenario—could be short lived if they can put the brakes on before momentum takes over.

55. Bond yields and inflation rise significantly, equity returns suffer. Hard to put numbers on it.

Question: 7. Guaranteed minimum income established in U.S. and most other OECD countries at 25% above poverty level.

56. Yang is campaigning on this already, conditional on increasing automation. If AI job replacement grows exponentially, then may put more pressure here.

57. Plausible but would require lots of public pressure that seems unlikely.

58. Needs inequality candidate.

59. Democrats are crazy enough to do it.

60. Well in the future if at all.

61. If it happens before 2030 likely to be right after 2024 election with a one-issue candidate focused on inequality.

62. Wishful thinking, but for that, the whole system should change, which is unlikely until a huge collapse.

63. The development would be inflationary.

64. Expect some inflation if not paired with higher taxes.

65. Bad policy like this will elevate interest rates and/or taxes. Corporations will get squeezed and their credit stressed. Might not raise taxes, but carrying huge deficits will just increase the effect in the same direction.

Question: 8. Federal debt to GDP ratio reaches 150%.

66. Not by 2030.

67. Would require a war or green new deal—unlikely; seems more likely to blow up before we get to 150%.

68. Given starting point and various headwinds from natural disasters to civil stuff, as well as lower future revenue generation (lower economic growth, population earning taxable income, tax rates).

69. We are on that type of trajectory now. Change of government to left will expand entitlements and possibly a single-payer healthcare system, which will easily blow us out to 150% GDP.

70. This will either happen or it won't—likely not a distribution to be followed.

71. If I could have answered 2050, I would have, per CBO in reference 1.

72. If it reaches 150% without blowing up the financial system that will truly be an unrivaled experience—hard to estimate variables since it seems like blow-up should occur before this.

73. Higher rates, especially corporate borrowing rates, are probable under such a scenario. However, we should remember that Japan has a debt to GDP ratio today over 200% and has managed to keep rates low. The devastation will come, but timing can be long in the tooth.

74. Again, depends on what else is happening in the world at the same time. Possible to reach 150% debt/GDP without catastrophic result if environment is benign. However, creates much higher risk in the system.

75. Need more credit.

Question: 9. Federal debt to GDP ratio reaches 50%.

76. What did we do to make this happen?

77. Requires voters to think long term. Unlikely to happen.

78. Very unlikely, so assumed end of period.

79. I have no idea, since we have high debt to GDP today and low CPI/10-year Treasury and 20% returns—it makes no sense in the long run.

Question: 10. U.S. taxation increased to a level that balances the budget.

80. Not in sight. Spending has to drop for this balancing the budget.

81. I don't see this happening in my lifetime, unless the world's financial system blows up first and this becomes required in the aftermath.

82. It is very unlikely that high earners would accept a tax increase to the point that it could contribute to balancing the budget, while taxing the increasingly impoverished middle-class would be counter-productive to say the least.

83. Requires a Democrat winning president (basically 50/50 given past few elections) and at least one part of Congress.

84. Not gonna happen. :)

85. Results back to somewhat normal.

Question: 11. Carbon tax is implemented worldwide.

86. Worldwide is too wide; better to say something like 50% of OECD countries.

87. Terrible idea that even the left knows is nonsense. The left has better ways to justify confiscatory taxation so is unlikely to press this as a global issue. At any rate, China will not go along.

88. While it is proven that the carbon tax doesn't impact Greenhouse Gas reduction, it is a way of taxing the many and, hence, might get implemented worldwide.

89. The development as stated is unlikely since it involves ALL countries.

90. If extreme events continue to get worse, this will be implemented along with other voter inequality measures. Carbon tax, taken further to reflect usage of scarce resources, is necessary as a minimum measure to clean up the atmosphere and general environment. This is a problem of double entry accounting that the accountants should fix.

91. This will be a tough sell, but if the world economy is not reduced to a Mad Max scenario, it is necessary.

92. Less impact than we think, because it would have to be so bad to be implemented that it will have little change.

93. Low probability, but if it happens, there will be some negative impacts (hopefully temporary) on global growth. Should not be catastrophic.

94. Seems independent of economic drivers, basically a cost hit.

Question: 12. The E.U. fails and countries/currencies regain independence.

95. Even if the E.U. will weaken, it is unlikely that the euro countries will get back to national currencies. However, a mismanagement of the European Central Bank is likely and that could contribute to a collapse of the international financial system.

96. Brexit may be but the first straw of the E.U. failing.

97. May still have some alliances/clusters.

98. The E.U. failing means loss of central bank and coordinated economic policy. We were close in 2010, and the negative rates policies in the E.U. are starting to be seen as the failures that they are. If E.U. GDP growth cannot be revived, failure is not far behind.

99. Not tied to presidential cycle—will take a while for momentum to grow toward dissolution.

Question: 13. US adopts single-payer health care.

100. More likely that the Obama health care system gets overhauled.

101. May be tied to other results—inequality wave of voters look at green new deal.

102. Some form may be passed, but the whole thing is so messy.

103. Wishful thinking, but the 20% of Americans that oppose it are way more influential than the 80% that support it.

104. Two election cycles needed to force this through.

105. Assumes Republicans maintain at least one of three seats of power until then. Will change quickly if Democrats get full control. Unlikely to be done correctly the first time.

106. Could be inflationary.

107 No real way to predict. Probably bad for economic growth and deficits. Higher rates and inflation and weaker equity markets probable.

108. May take a few years to settle down the markets to stability.

109. Slowdown in economic growth.

110. Need more credit, so rates go up. Health insurers take a hit.

Question: 14. Wealth inequality—the dozen countries with the highest current wealth gap between richest and poorest people enact political and economic reforms designed to close the gap within three years.

111. Three years is too fast.

112. No way to deal with an effect that is a consequence of normal economic forces. The one exception is China where it is largely the result of corruption and unrest could take a toll.

113. The gap is a real irritant. In many countries will lead to political turmoil.

114. War is the likely trigger for this reset.

115. Misaligned incentives make this one unlikely for many years, but eventually it will cycle.

116. Closing the gap will cost a lot, therefore inflationary.

Question: 15. National elections in the U.S. become chaotic to the extent that violence often erupts quelled by armed force.

117. Turning arms on citizens is bad optics, expect other solutions. may have pockets of civil unrest/protests.

118. God help us if we take this path.

119. If Trump declares that anti-Trump attitudes are treasonous.

120. If Trump is alive and won in 2020, he will try to stay beyond eight years.

121. This would be very disruptive and leave scars for generations.

Question: 16. Trade tariffs and currency wars double in number and size in relation to 2019 levels.

122. Doubling is too large of magnitude. Higher probability of some increase.

123. Depends on U.S. election outcome.

124. When E.U. and U.S. politicians will realize the level of impact of Chinese power on the financial, economic and political order, drastic measures might be implemented.

125. If Republicans remain in presidency, seems more likely in term starting 2021. A deal is not always good, but doing nothing may be better than increasing tariffs that can be retaliated against.

126. Second Trump term seems likely to lose control of trade.

127. All numbers are wild guesses. Directional effects are based on the growth reducing consequences of trade wars (poor equity) and inflationary effects of tariffs.

128. Continuation of current trend. Economic headwinds. Central banks trying to support with limited success.

Question: 17. Tariff and trade wars are resolved.

129. Unlikely because they have become an instrument of foreign policy. Why are other respondents so optimistic; has it ever happened? Is it more or less likely in our world and time? Yet Trump may see this as a useful instrument in his reelection bids.

130. 2030 is a long time away—doesn't seem likely under current administration.

131. If major disputes resolved, it will happen early in the next presidential cycle.

132. Very unlikely ALL will be resolved, but I have interpreted this to mean back to normal.

133. Some degree of mean reversion—hopefully gets back to normal at some point. Trade reduces the likelihood of war as well.

Question: 18. U.S. armed conflict with one or more major nations, involving more than 50,000 U.S. troops.

134. China or Iran are serious possibilities for conventional conflict. In the case of North Korea, I fear it would be weapons of mass destruction. Other regions could erupt such as the Middle East.

135. Lots of options for opponents, but who will partner with U.S.? Will NATO stay neutral during conflict between U.S. and China/Iran/Russia/India?

136. God, hope we can avoid the. When does rationality return to the world? I increased my estimate when news of U.S. killing of Iran's top general broke.

137. Cannot say, no reason to believe the threat is not fairly uniform over time.

138. Trump uses war as a reason he should stay beyond two terms.

139. Who: China, Iran, North Korea? Three good candidates. I changed my estimate to a closer time when news of U.S. killing of Iran's top general broke.

140. Armed build up requires military spending, and that stimulates the economy.

141. Impact larger than would be if lower debt to GDP ratio at beginning—could cause currency default/hyperinflation.

Question: 19. Incumbent loses reelection in 2020: U.S. policies revert to former era.

142. This statement includes two questions, which do not necessarily support each other. Even if the incumbent loses reelection in 2020, U.S. policies do not necessarily revert to former era.

143. This is best case if Trump loses and could happen if Democrats don't control all branches. May be compromise to avoid Green New Deal spending disaster (ideas good, but pay for them now).

144. The U.S. would regain respectability, rejoin the Paris Accords, reinstate many regulations that the current president's policies cancelled.

145. Good chance incumbent loses. Not certain policies revert when that happens.

146. 4Q2020 after the election but before inauguration will be a wild time if Trump loses. Otherwise next four years will be crazy as lame duck president.

147. Negative for U.S. business—shifts in competitiveness and wealth.

Question: 20. Major hack cripples the financial system for one month; 50% of individual depositors and corporations cannot reconstruct the amounts in their accounts; stock trades must be documented by hand.

148. Could be longer than one month and very debilitating. Would have a chilling effect on internet forever.

149. If redundancy is built NOW, then hack will not have such large ramifications. I'm more worried about a hack of the power grid.

150. It's not a matter of IF, but WHEN and how resilient is the system to such a hack.

151. Capability likely available now—would require war scenario for it to play out—otherwise downside is too high for perpetrator.

152. Some effects would be lasting (e.g., distrust of online transactions); others temporary, say one year to recovery; consequence would be further tightening of internet and penalties or hackers. But as I noted, some effects would be lasting. In my answers here, I have shown the long-term guesses; the short-term values would be (guess) twice as high.

Question: 21. Rapid growth of the use of robotics and artificial intelligence in major economies worldwide; machines take over one-third of today's jobs.

153. Its coming, but by 2030. We will have new jobs and service sector will grow even more.

154. Similar to 1900 when 25% of people serviced horses, either growing crops or cleaning up after them. New jobs were developed.

155. Already happening.

156. Almost a given.

157. Not discontinuous—moving this way now.

158. Will be gradual; we are already on that path.

159. The real change and the real uncertainty comes with the evolution of this technology to general artificial intelligence. This is the transition that Hawkings and Musk and many others have warned about—it is a transition when machines can indeed take over or move us to a new intellectual and social plateau.

Question: 22. Price of oil drops below $30 for more than a year.

160. Fracking in U.S. created nearly all new jobs since 2008—could be a big deal economically and not in a good way.

161. Serious economic collapse is the most likely cause. Even then, energy demand continues to grow.

162. Has great effect on Saudi Arabia and all OPEC countries. I assume that alternate fuels drive down the price rather than some revolution in demand.

163. May be slow trend or sudden change as conditions change.

164. Why does this development happen? Three possibilities: more oil deposits discovered, alternate fuels take meet the demand for energy, or price-cutting among suppliers: all plausible.

165. I have assumed that the US leads in the production of alternate energy sources and helps make carbon sources obsolete. That oil prices drop so low is a last gasp of the industry to stay in business.

166. Overall impact is low—realization that oil is not as important to global markets as it used to be.

Question: 23. Climate change remediation programs prove to be ineffective; food prices rise 20%.

167. Lab-grown food may increase availability.

168. Too little and too late. But a few programs work. If this happens, starvation increases and public welfare expands.

169. The Arab Spring was a precursor to food shortages around the world driven by climate change.

170. Not clear that climate change will reduce food output. Certainly there will be no real reduction in greenhouse gas emissions by 2030.

171. Present climate change programs are a joke. But beside that, climate change will be used as an excuse for continuous food prices' rise.

172. A tipping point is coming as jet stream becomes weak, initially cooling northern climates as warmth enters Arctic and Gulf Stream weakens, then warming everywhere. Hard to predict dates.

173. The impact will be long lasting and perhaps irreversible, also many effects beyond food prices.

174. I have guessed at relatively minor economic effects, but some of the worst consequences (e.g., loss of species, opening the Arctic to commercial vessels in a new route across the Arctic ocean—and territorial disputes) cannot be measured solely in economic terms

Question: 24. Perceived life expectancy at birth in the U.S. increases to 90 years.

175. There will be many people living with the expectation of living past the age of 90, which will change behavior with respect to savings, annuities, Social Security. But they may not live that long.

176. Medical advances offset poor diets and exercise to extend lifespan for many. Deaths of despair (suicides, opioids) often economically driven.

177. Given the recent changes in life expectancy and the slowdown in mortality improvements due to a host of factors, I believe the chances of hitting a life expectancy of 90 years by 2030 are low. With a longer time frame, this is more likely.

178. Medical advances are the driver here, and it seems likely that a major set of advances will push life expectancy at birth into triple digits by 2030.

179. High pace of med tech.

180. I think it will happen but may have shortening lifespans first due to deaths of despair and poor habits.

181. Perceived is a key word here. Most people who would be following a live-longer routine would think they would live long lives, but they really would not know if they would indeed live longer. Nevertheless, they would make at least some decisions differently as a result of that assumption that could affect the economy.

182. This is likely a gradual change so assumed no discontinuities.

Question: 25. Pandemic kills 1% of the world population (Spanish flu of 1918 is estimated to have killed between 50 and 100 million people worldwide).

183. Possibly a weapon that escapes from a bio-lab. But 1% of the world's population is huge, some 100 million people, so I have been conservative in my probability estimate.

184. Permafrost, bioterrorism, antibiotic resistance, spillover effects are all reasons why this could happen. WHO is slow to react and allows countries to hide developments until it is too late.

185. Climate change plus increased concentration of human populace in population centers will lead to higher chances of a pandemic.

186. Most probably a man-made pandemic.

187. Hard to put a date on it. 1% seems high since 2018 (over three years) was .6%.

188. Although the Spanish flu of 1918 did indeed kill millions, the happy years of the flapper of the 1930s followed. The dead were buried and life went on. My answers have assumed the same kind of socio-economic response. But certainly in the midst of the pandemic things would slow, pessimism would reign.

Question: 26. Natural disaster kills 100,000 in the U.S. (e.g., earthquake in Los Angeles or Puget Sound).

189. As likely next year as in 20 years. But when? Why are others entering such high probabilities? 100,000 people killed would be enormous, unprecedented.

190. This is another inevitable but hard to predict timing.

191. LA is expected in the public mind—Seattle will be a surprise, but it shouldn't be. That one will have huge economic impact.

192. This is one of those events that have a flat probability curve. Any time is as likely as any other. However, mitigating the impact is the possible development of predictive technologies.

193. Regional economic effects would be large; national, less so.

Question: 27. Massive terror attack kills more than 10,000 people in the U.S.

194. Terrorists are looking for a spectacular show that exceeds 9/11. Artificial biological epidemics may be their weapon, so I judge this as plausible. Even a subway attack at rush hour could do it. It would be three times larger than 9/11.

195. So far mostly idiots trying this stuff. If state sponsors get involved (we've seen Russia do things in Europe/U.K.), the likelihood becomes high, as it would not be that hard to pull off (e.g., anthrax off Sears Tower or Empire State Building).

196. Tied to aggressiveness of state sponsors. Unlikely that ISIS-type organization could pull it off. Today more likely wacko American.

197. This is one of those developments that could happen at any time. All of the technological pieces are in place.

198. Would throw U.S. into turmoil, lasting 10–20years. High cost to freedoms and privacy, panic, panic. More expenditures on a new hot war on terror. Big brother facial recognition. Government control over internet and content.

199. This type of event could trigger velocity of money to spike, unleashing hyperinflation when combined with high debt to GDP starting point.

Question: 28. Space travel becomes economical for 10% of US citizens.

200. Ten percent is too high. Implies about 40,000,000 space tourists. Wow! And implies a ticket price of under say $250. Even if we are talking about a ballistic flight to 100,000 feet above the earth, this development would be hard to imagine.

201. It is unlikely that there will be political willingness to support space travel for the many.

202. Seems unlikely (but cool if true!).

203. Unlikely to be affordable to 10% within the next 10 years, but within a longer timeframe, it is more likely for travel to near space (e.g., http://www.zero2infinity.space/bloon/).

204. May depend on Bezos and Musk successes, since they are funding developments.

205. I have made it as late as possible in the acceptable window.

206. My estimates are as high as I have indicated, because I assume that if everybody can afford this ride into space, the economy must be doing pretty well.

Question: 29. Other developments that you think we should consider?

207. How about: Guilty in an impeachment trial, or the opposite revote on Brexit—U.K. stays in E.U. Chinese socialism fails.

208. E.U. gets irrevocably under Chinese influence, as do Latin America and Africa.

209. China blows up—due to economic and social factors. Regional wars driven by climate change (e.g., fight over fresh water sources).

210. The U.S. Government is overthrown or is turned into a dictatorship.

211. Fresh water availability; new nuclear energy tech; ocean level; digital currencies; other decentralized means of transaction (voting); migration/immigration trends.

212. Hyper-connectivity (of all things and people) ensures to complete lack of privacy, leading to a large segment of the population electing to go off the grid, forcing a dramatic shift in community dynamics, workforce solutioning, food security, and more. Gig working grows in popularity and leads to millions being employed fully but underprotected by traditional employer-provided safety nets (health insurance, life insurance and retirement benefits, to name a few). Underrepresented populations gain political traction

and force, leading to shifts in systemic regulations and increased access to economic means for more citizens.

Appendix D Methods

D.1 DELPHI AND REAL TIME DELPHI

The Delphi technique was developed at RAND in the early 1960s by Olaf Helmer, Nicholas Rescher, Norman Dalkey, and others.[3] Its philosophical base was described by Helmer and Rescher (1959). Literally thousands, perhaps tens of thousands, of studies requiring the elicitation and synthesis of expert judgments using this method have been conducted over the past decades since its introduction. It has proven to be a useful technique for eliciting judgments from expert groups and is normally administered in the form of sequential questionnaires, each round building on the preceding one and asking respondents who hold extreme views to state the reasons why they hold these positions; the next round then presents these reasons and asks for reassessment by the group. This process often leads to convergence of opinion. The keys are anonymity of participants in the sense that no comments are attributed to a person and feedback to drive toward consensus.

Despite its popularity, Delphi studies take a long time to complete (on the order of months) and have been expensive: A single round can easily require three weeks; a three-round Delphi is at least a three- to four-month affair, including preparation and analysis time. Real Time Delphi is an online version but faster and less expensive system.

While Delphi had its birth in concern about spurious factors that intrude in face-to-face meetings among experts, new communication technology can minimize some of these factors. Some Delphi-like studies have been performed online (Shota, 1993), and applications date back to the 1970s when Murray Turoff experimented with early computer-based communications to link experts together in networks (Turoff, 1972). More recently, he and his colleagues have described a Social Decision Support System in which large groups of people (thousands) interact and vote dynamically (can change votes as in Delphi) on social issues. (Turoff, Hiltz, Cho, Li, and Wang, 2002)

In September 2004, the Defense Advanced Research Projects Agency awarded a Small Business Innovation Research grant to Articulate Software, Inc. to develop a Delphi-based method for improving the speed and efficiency of collecting judgments in tactical situations where rapid decisions are called for. The grant was based on a decision-making problem: a hypothetical decision-maker, uncertain about tactics that might be followed in accomplishing a specific objective, calls on a number of experts to provide their judgments about values of the alternative approaches. Delphi was specified in the grant as the method to be employed. The objective was to improve the speed of the process, to real time if possible (hence the name: Real Time Delphi). The number of participants representing different areas of expertise was assumed to be small, perhaps 10–15 people.

The Real Time Delphi design that emerged permits synchronous or asynchronous participation by any number of panelists, the process offers speed, efficiency, transparency to the study administrators, and flexibility to the participants.

When each respondent joins the ongoing study, he or she is presented an onscreen questionnaire form. There are boxes for write-in responses to the questions posed or a Linkert scale of check boxes for answering.

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[3] The author had the good fortune to be able to contribute to the first RAND external Delphi: Gordon, Theodore, and Olaf, Helmer-Hirschberg. Report on a Long Range Forecasting Study. *RAND*, September 1964, *https://www.rand.org/pubs/papers/P2982.html* (accessed April 26, 2020).

The group average or median to that point is shown. In considering his or her answer to each question, the respondent may open a new page that shows the reasons others have given. Considering this information, the respondent provides a numerical input. The group average or median is updated immediately and presented back to the respondent and anyone else who has signed on, along with the number of people who have contributed to the group response.

There is no explicit second round. When the respondent comes back to the study in a minute or a day, the original input form is presented to him or her. Of course, by then others may have contributed judgments, the averages or medians may have changed. In this way, the Delphi requirements of anonymity and feedback are met, and the process—once underway—yields the distribution of the group's responses and reasons for the extreme positions. The process can be synchronous or asynchronous, and if implemented on an internet site, can involve a worldwide panel. The administrator can publish a cutoff time (an hour, a day, a week or a month away) and encourage participants to visit the site often before that time. There will be no "stuffing of the ballot box" since each participant has only one form—the original form—that is always brought back when the participant revisits.

A useful and authoritative reference is *The Delphi Method* (Linstone, Harold, and Murray Turoff, 1975).

D.2 CURVE FITTING

Curve fitting involves finding an equation which best fits a set of historical data points. Many commercial software packages provide the easy solutions to this problem. Typically the user supplies historical data points and the software goes through a set of equations to find the equation that has least error expressing the historical data. The equations used in this type of analysis include straight lines, parabolas, sinusitis, et cetera, and will through iteration find the curve type that best approximates the given data points. Imagine that you have 20 years' worth of annual data of say, GDP/capita. The automated process in which the software of a commercial package engages takes each curve in turn, computes the value of GDP/cap for each year, observes the error between that computed value and the true value, and aggregates the errors. By changing the coefficients of the equation, it seeks to minimize the aggregate by "moving" the curve among the data points. The curve gets this score. Then a second curve shape is attempted and scored, and finally the software lists the curves in the order of their scores, minimum accumulated error being best. There are statistical short cuts in this process; the "goodness of fit" is measured by a parameter known as r^2 or "coefficient of determination."

The commercial package used in this study is CurveExpertPro , described on its website as follows:

> CurveExpert Professional is a cross-platform solution for curve fitting and data analysis. Data can be modelled using a toolbox of linear regression models, nonlinear regression models, smoothing methods, or various kinds of splines. Over 90 models are built-in, but custom regression models may also be defined by the user. Full-featured publication-quality graphing capability allows thorough examination of the curve fit. The process of finding the best fit can be automated by letting CurveExpert compare your data to each model to choose the best curve. The software is designed with the purpose of generating high quality results and output while saving your time in the process.[4]

A typical output of CurveExpertPro is shown in Figure 16 for CPI as used in this study.

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[4] Hyams Development. CurveExpert Professional. *https://www.curveexpert.net/products/curveexpert-professional* (accessed April 26, 2020).

Figure 16
CURVEEXPERTPRO TYPICAL OUTPUT
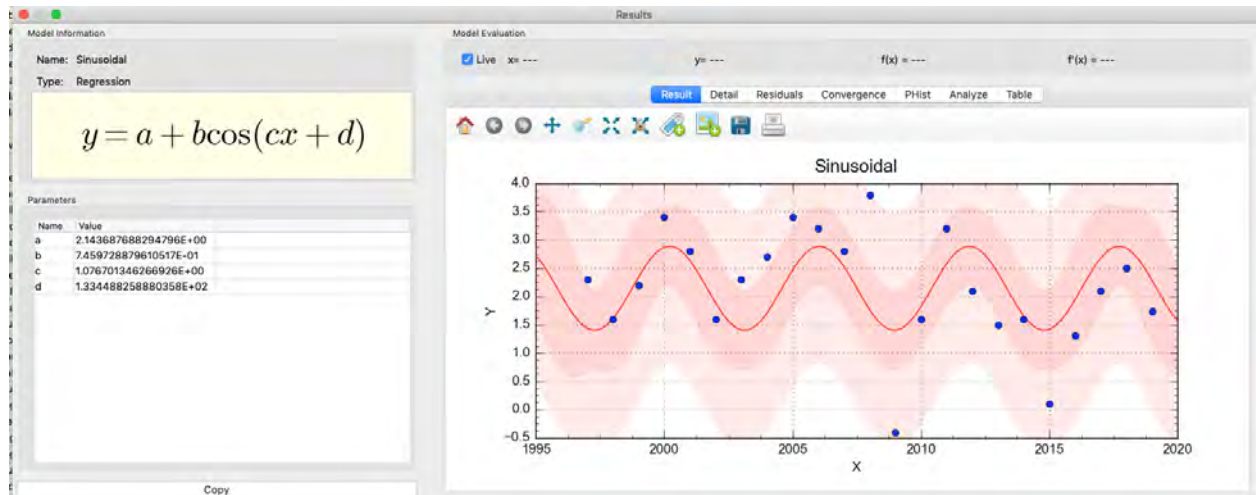
CurveExpertPro attempted to fit scores of equations to the given data points and found that the curve that best fit the data was a sinusoid, which is plotted in the graph on the right. The coefficient of determination is 0.2855, which is the best fit among the equations examined but not superb; nevertheless the sinusoid was used to project the next 10 years as shown in Figure 17. The analyst must judge whether the forecast is plausible.

Figure 17
IS IT PLAUSIBLE?
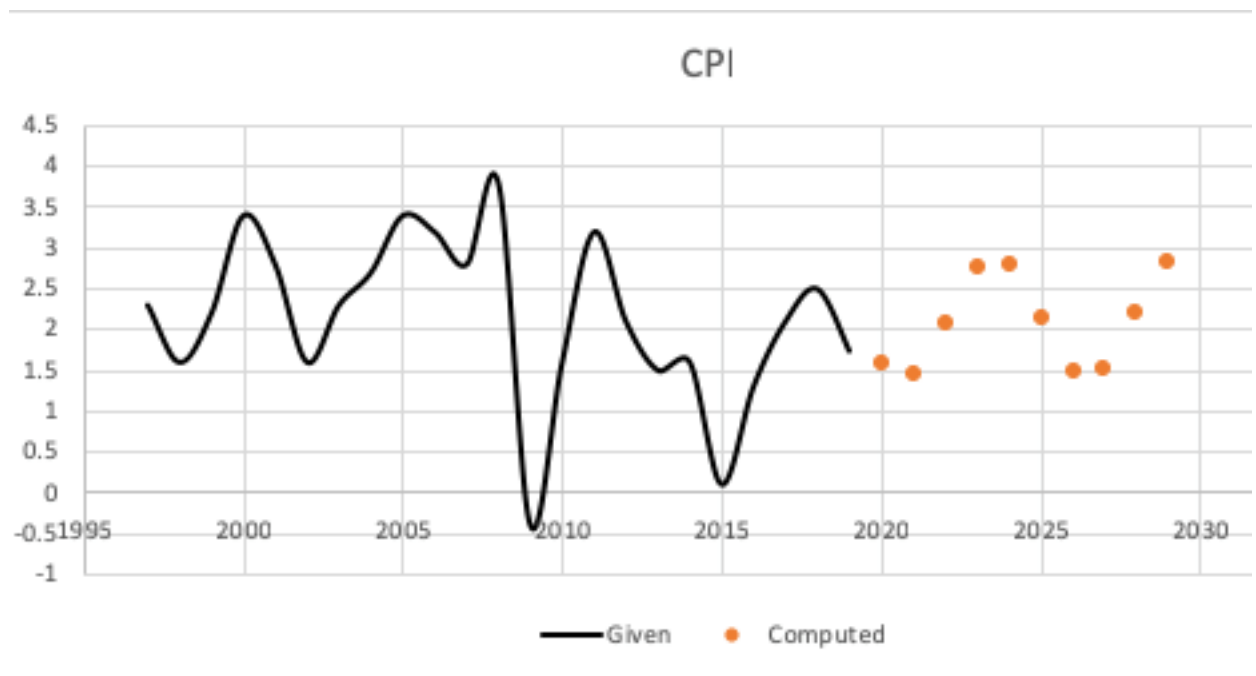
The recommended reference on curve fitting is "Extrapolation for Timeseries And Cross-Sectional Data" (Armstrong, J. Scott, 2001).

D.3 TREND IMPACT ANALYSIS

TIA is a forecasting method that permits extrapolations of historical trends to be modified in view of expectations about future developments. This method permits an analyst, interested in tracking a particular variable, to include and systematically examine the effects of possible future external developments that are believed to be important to the future course of the variable. The developments can include technological, political, social, economic and/or value-oriented changes.

Surprise-free extrapolation is the first step (see Appendix D2). Most curve-fitting routines specify the equation of a curve that best fits a set of historical data; that is, falls as closely as possible to the given data. The algorithm then extrapolates the curve to generate the surprise-free forecast. Selection of the proper general curve shape can be difficult. Two different curve shapes, for example, can each fit the historical data well and yet produce markedly different extrapolations. In effect, selecting the curve shape predetermines the surprise-free forecast. In practice, a number of different types of curves are used to fit historical data, ranging from straight lines, to complex s-shaped curves.

Judgment and imagination are crucial to the second step of TIA. In a TIA, the surprise-free extrapolation is modified to take into account important unprecedented future developments.

First, a list of such potential developments is prepared. The source of this list typically may be a literature search, a Delphi study or an informal consensus among consultants. The developments selected comprise an inventory of potential forces that could lead to a departure from a surprise-free future.

Several judgments are made about each development. First, estimates are made of the probability of occurrence of each development as a function of time. Second, the impact of each development on the variable under study is estimated. Impacts can be specified in several ways; one procedure involves specification of time from occurrence of the impacting development until:

1. the variable begins to be affected;
2. the impact on the variable is largest; or
3. the impact reaches a final or steady-state level.

1. the maximum impact; or
2. the steady-state impact.

Figure 18 illustrates the parameters that can define an impact:

Figure 18
DESCRIPTION OF A DEVELOPMENT'S IMPACT
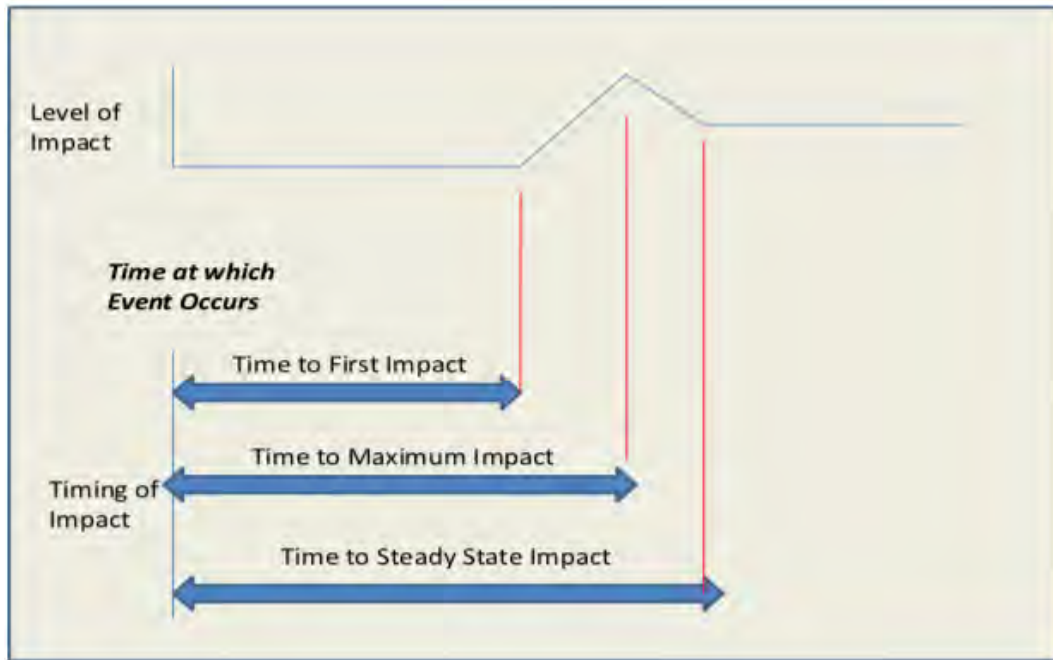
Source: Chapter "Trend Impact Analysis" by T. Gordon; Futures Research Methods v3, a CD ROM, The Millennium Project, Washington DC.

Each of the three specified times and the two magnitudes of impact associated with them are taken as completely independent. For example, the maximum impact may be positive and the steady-state impact negative, or the steady-state impact may be zero and the impact only temporary. Finally, the maximum impact may be the same as the steady-state impact. Of course, the impact shape could be stated in other terms, but the five parameters used here have proven applicable to most situations.

The TIA computer program combines the impact and event-probability judgments with results of the surprise-free extrapolation to produce an adjusted extrapolation. This analysis typically includes estimates of upper and lower quartile limits or limits at some other probability levels. The expected value of the combined impacts is computed by summing the products of the probabilities of impacting events for each year in which they were possible with the magnitude of their expected impacts, taking into account the specified impact lags. The simplest approach treats the events as though they were independent of one another.

A Monte Carlo approach is used for this (see Appendix D4). This analysis typically results in estimates of upper and lower quartile limits or limits at other probability levels.

A recommended reference on TIA is "Trend Impact Analysis in Future Studies" (Abbasi, A. Hesam Saken, and Moshen Baharmi, 2015).

D.4 MONTE CARLO ANALYSIS

Monte Carlo analysis is means of simulating real-life processes that involve randomly determined outcomes. Kenton (2019) defines the process as follows:

> Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used to understand the impact of risk and uncertainty in prediction and forecasting models.

> Monte Carlo simulation can be used to tackle a range of problems in virtually every field such as finance, engineering, supply chain, and science.

Our use of Monte Carlo analysis in this study involved a large number of simulations each of which began at the present and stepped forward a year at a time to compute the value of each of the 4 variables in each year of the next decade. Determination of whether or not a development happened in a future year was based on a random number draw. A random number between 0 and 1 was compared with the probability of each development at each time; if the probably was higher than the random number the development was assumed to have occurred and the value of each variable was adjusted according to the impact estimates produced in RTD2. This process was repeated to the end of the forecast interval and the data for the single run was saved in a data base. This process was repeated 100 times using an Excel macro; each of the 100 runs differed, of course, since different developments we decided to have occurred in different sequences in each run according to the chance of random numbers. The set of 100 runs took about 5 seconds to complete. For an example, see Figure 7 in Section 9.

Recommended references are "Statistics How to: Monte Carlo Simulation/ Method" (Stephanie, 2015) and "Monte Carlo Simulation Definition" (Kenton, 2019).

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