Disruption Index Methodology
2018-2019 Vehicle Innovations Challenge

Forecasting tournaments are online competitions lasting over several months in which individuals compete for the most accurate forecasts on a range of important topics in the form of questions. For example, one question in a tournament could be “Will Justin Trudeau cease to be prime minister of Canada after the next federal election?” and an individual’s forecast would be their 0%-100% probability that the question would resolve as “Yes”. We hold a forecasting tournament called “2018-2019 Vehicle Innovations Challenge” on our affiliated crowd-prediction platform Good Judgement Open (GJO), which specializes in running such tournaments. Since November 2018, we have posted questions regarding future changes to technological advancements, regulatory policies, or demand associated with electric vehicles (EVs) and autonomous vehicles (AVs). As outlined in the Appendix, each of these questions went through a rigorous process to ensure they are relevant to the long-term disruption of a given emerging technology. Forecasters on GJO forecast questions by distributing a total of 100% probability among the options in any given question. For instance, in a four-option question, a forecaster could forecast A = 10%, B = 30%, C = 60%, D = 0%, totaling 100%. At any given time, each question has a "consensus" probability for each question option based on the median of probabilities made by all active forecasters on that question at that time. We utilize these consensus probabilities to generate our indexes as outlined below.

With the aid of GJO, we first considered which question options in each question are "bullish" (if the question option were to occur the disruption of the focal technology would accelerate) or "bearish" (if the question option were to occur the disruption of the focal technology would decelerate), or “neutral" (if the question option were to occur the disruption of the focal technology would not change). For instance, consider the question "Before 1 January 2020, will General Motors launch a ride-hailing service open to the public in the U.S. which uses autonomous vehicles?" with four question options as follows: A = "Yes, using only vehicles with steering wheels" B = "Yes, using only vehicles without steering wheels", C = "Yes, using at least some vehicles without steering wheels", and D = "No". If options A, B, or C were to occur the disruption of the focal technology (AVs) would accelerate and therefore these three options are considered "bullish" options. On the other hand, if option D were to occur the disruption of the focal technology (AVs) would perhaps decelerate given that Mary Barra, CEO of GM, was outspoken about this goal and therefore this option is considered a "bearish" option. There are no neutral question options in this question. We coded each question option for each question as either bearish, bullish, or neutral in this manner. We then take the following steps:

1. We obtain the "consensus" probabilities discussed above for a question on a given day and sum up the probabilities of designated "bullish" options and separately sum up the probabilities of "bearish" question options for the question.

2. We then subtract the summed "bearish" options probabilities from the summed "bullish" options probabilities. A difference measure greater than zero indicates the consensus is "bullish", a difference measure less than zero indicates the consensus is "bearish", and a difference measure equal to zero indicates the consensus is “neutral” for that question at that time. Bullish questions on a given day are set to +1, bearish are set to -1, and neutral are set to 0.
3. We then weight these values according to their relative importance to the long-term disruption of the technology. We obtain these weights from our panel of auto industry experts and elite forecasters who suggested the relative impact that each question topic would have on the overall disruption of the focal technology if the question were to resolve positively. For example, our panel believes that if there is "a steady rise in gas prices" by the end of 2019, the likelihood of a long-term bullish outlook for EVs is 26% higher than if there is not "a steady rise in gas prices" by the end of 2019. Accordingly, the associated tournament question of "What will be the price of regular gasoline in the U.S. per gallon on 30 December 2019?" has the "diagnosticity" percentage of 26%. We use these "diagnosticity" percentages for each question to weight the effect of the question's bullish or bearish designation on a given day on a disruption index. For instance, if on a given day the EV Index consisted of two questions that were "bullish" and "bearish" with "diagnosticity" percentages of 31% and 24%, respectively, the Index would be slightly "bullish". Each index ranges from -100, indicating the consensus is "bearish" on all questions related to the focal technology, to +100, indicating the consensus is "bullish" on all questions related to the focal technology.
4. We track these indexes historically on a monthly basis starting on March 14th 2019, the date at which we had a satisfactory number of questions that had been launched on GJO.

APPENDIX

Short-term Indicator Generation Report

We set out to systematically gather insight from various stakeholders within the automotive ecosystem as part of a broader effort to test the viability of a crowd-based business intelligence tool that would monitor disruption and tipping points in the automotive industry, particularly regarding electric and autonomous vehicles. Accordingly, we collected a list of potential short-term events (indicators) within the automotive ecosystem, the outcome of which would be indicative of the long-term disruption (5-7 years out) with respect to electric vehicles and autonomous vehicles. We outline our process and findings below.

Panel of survey respondents

In order to best harness the wisdom of the crowd, we hand-picked panel members who were either individuals with unique perspectives within the global automotive ecosystem or individuals with elite forecasting track records regarding the automotive ecosystem.

The complexion of the experts within our 34 member panel includes:

- Typical level of participant: Sr. Manager or above
- Average experience in the auto industry: 13
- Markets: Representation from Europe, Asia, and the U.S.
- Organizations represented: OEMs and other manufacturers (Nissan, Waymo, Tesla, Baidu, Daimler, GM, Audi, VW, Huawei, Cummins), Policy (Colorado Department of Transportation, Tai Ginsberg & Associates), Consulting (Oliver Wyman), and academics (Wharton)

Good Judgment Open

The input from this panel have been used as the basis for forecasting questions on our third tournament held on Good Judgment Open (GJO), the crowd-based forecasting platform. Combining the wisdom of our esteemed panel with the wisdom of the crowd, we feel confident that the real-time predictions on GJO have relevance to key stakeholders of the global auto industry.

Ranked short-term indicators

Below are two tables highlighting the key short-term indicators driving long-term disruption in autonomous vehicles (AVs) and electric vehicles (EVs), respectively, generated and ranked by our panel of experts and elite forecasters. Please refer to the footnotes for details on "diagnosticity" calculations.

Autonomous Vehicles: importance of short-term indicators driving long-term disruption

Rank	Indicator	Diagnosticity*
1	At least one L4 passenger car becomes commercially available	32%
2	A major supplier to auto manufacturers offers a cost effective sensory system that works in all weather conditions and times of day	30%
3	Successful pilots of AV ride hailing services in multiple major US cities	30%
4	Global standardization of APIs in cities and among car manufacturers for vehicle-2-vehicle communication	26%
5	Legal clarity regarding responsibility in case of accident/death etc.	24%
6	Significant drop in the price of commercially available LIDAR units	24%
7	There are very few fatal accidents attributed to failings of autonomous cars (Level 4 and below	25%
8	U.S. law passes that increases the number of exemptions for AVs allowed per manufacturer by the Federal Motor Vehicle Safety Standards	20%
9	Standards for safety and validation & verification are set by auto industry leaders	20%
10	A major supplier to auto manufacturers offers significantly improved HD mapping and navigation technologies	17%
11	Fewer traffic accidents related to AV testing as compared to 2018	16%
12	Implementation of true 5G networks in several major city	15%
13	A significantly large open source software crowd is mobilized to improve quality of reliability and diffusion of AV software	13%

* The diagnosticity percentage is the estimated increase in probability that the long-term Bullish Scenario (see below for details) of a focal technology (i.e., autonomous vehicles (AVs), elective vehicles (EVs)) will occur if a given indicator were to occur by the end of 2019. For example, if there is "a steady rise in gas prices" by the end of 2019, our auto industry experts and elite forecasters predict that the likelihood of a long-term Bullish Scenario for EVs is 26% higher than if there is not "a steady rise in gas prices". As a word of caution, the values of diagnosticity in this report is less important than the relative size of these values.

These diagnosticity values are computed as the weighted average of survey responses for each indicator in response to the following prompt: "Please indicate how much more likely the 'Bullish Scenario' (as described below) would ultimately become reality if a given short-term indicator were to occur by the end of 2019." These values are weighted by the number of respondents who answered each question option (e.g., 0%, 10%, 20%).

The Bullish Scenario for AVs was "By year-end 2025, self-driving passenger cars – fully autonomous in certain geographic areas and conditions (i.e., Level 4) – will account for much MORE than 500,000 (~0.5%) of all global new passenger car sales", based on recent reports from *McKinsey*, *IHS Automotive*, and *Catapult Transport Systems*.

Electric Vehicles: importance of short-term indicators driving long-term disruption

Rank	Indicator	Diagnosticity*
1	Industry wide Li-Ion battery cost per kWh will decline significantly	30%
2	Regular production of EVs with range capacity comparable to ICEs	30%
3	Major Increase in U.S. federal EV tax credits	28%
4	Proliferation of DC fast charging stations	29%
5	EV market share in China increases significantly	28%
6	A battery technical breakthrough occurs as an alternative to Li-ion such as solid-state batteries	27%
7	A steady rise in gas prices	26%
8	The amount of public charging outlets for EVs increases significantly	25%
9	Auto makers increase incentives to dealers to sell more EVs	22%
10	Car makers offer significantly more EV model options	21%
11	Tesla begins to sell the Model 3 with a true starting price of $35K (before incentives)	18%
12	Increased collaboration between car manufacturers and technology companies	17%
13	Industry standardization of EV charging plugs	16%
14	Tesla surpasses their Model 3 delivery goals	13%

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The Bullish Scenario for EVs was "By year-end 2025, EVs (battery electric vehicles) will account for much MORE than 11 million (~10%) of new passenger car sales", based on recent reports from *Bloomberg New Energy Finance*, and *Research & Markets*.