Editorial

by Gurumurthy Kalyanaram

Covid-19 Decisions, and Decision-Making Models

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Covid-19 has imposed upon governments very consequential decisions about closing the economy/society and opening the society/economy. Such decision-making can adopt one of two models: compensatory model or a non-compensatory model.

Decision Making Models and Algorithms

Compensatory decision making involves identifying a set of criteria relevant to the decision, assigning a relative importance weight to each criterion (the sum of all the relative importance weights must add to one), assessing the performance of each criteria, computing an overall composite score for each option, and selecting the option with the best score. The model is based on utility theory. They are rational decision choices that are represented by multi-attribute utility models (Keeney and Raiffa 1976).

In our context, it is a binary decision: to reopen or not. Here, the compensatory model will provide a composite score. The economy will be reopened if the composite score is above the score advocated by the decision maker prior to the calculation.

As an illustration, let us assume that a policy maker considers only these three criteria for his region: infection rate, hospital capacity and testing capacity. Let us assume that based on inputs from experts and statistical models, the assigned relative importance weights are 0.5, 0.25 and 0.25 respectively (the sum of relative importance weights must add to 1). And the region's performance on each criterion is rated to be 3, 4 and 2 (on a five-point scale) respectively. The composite score is 3.0 (0.5x3 + 0.25x4 + 0.25x2). The maximum possible score is obviously 5.0 if the region was assessed to be well in all the criteria (0.5x5 + 0.25x5 + 0.25x5). Based on expert and prior data input, the policy maker sets the cut-off score at 4. Given this cut-off, the region is not evidently ready to be opened.

The non-compensatory decision making involves identifying a set of criteria relevant to the decision, and assigning an acceptable threshold value for each criterion (Einhorn, 1970). The non-compensatory model has two principles. The first principle is that of sequential consideration of criteria. The sequence generally follows a pattern such as the most important to least important attribute or feature. But the sequence may also not follow any pattern. The second principle is that of a critical tolerance or threshold level for each attribute. Unless the attribute satisfies the threshold levels for each attribute, the choice is discarded. This is similar to the satisficing principle proposed by Simon (1955).

In a non-compensatory model, decision-makers are interested in certain threshold levels on each criterion. Values greater or less than the threshold value are, of course, welcome, but the threshold level is sufficient. For instance, a policy decision-maker may want positive test rate for the virus to be no more than 1.5 percent, at least 25 percent of beds to be available for Intensive Care Unit (ICU), and capacity to conduct at least 20,000 tests a day. If the respective values are 1.2 percent, 30 percent, and 22,000, then the region is ready to be opened. On the other hand, if the respective values are 1.2 percent, 20 percent, and 22,000, the region is not ready to open because the availability of ICU beds is less than the threshold value.

See Table 1 for a representation of the two models (compensatory and non-compensatory), and their decision algorithms and outcomes.

Table 1: Decision Making Model Framework

MODEL	DECISION ALGORITHM	DECISION OUTCOME
COMPENSATORY	Criteria compensate for each other Enumerate the criteria for reopening (e.g. infection rate, hospital capacity, testing capacity) Set the relative importance weights for each criterion based on judgment-- the total must add to 1 (e.g., 0.5, 0.25, 0.25); and Assess/Rate the status/performance on each criterion on a scale (e.g., 3, 4, 2 on a five-points scale)	Compute a Composite Score: Sum of Weight x Rating over all criteria If the Score is above a pre-determined number, then the Decision is a GO
NON-COMPENSATORY	Each criterion has to fulfill a threshold value – a value determined by the Decision-maker Enumerate the criteria for reopening (e.g., test rate, hospital capacity, testing capacity); and Set the threshold value for each criterion on relevant scales (e.g., maximum of 5 percent positive test, minimum of 25 percent ICU beds, ability to test at least 20,000 per day)	Assess if each criterion has fulfilled the threshold requirement If all the attributes fulfill the threshold values, then the DECISION is a GO

Sources for Inputs, and Model Efficiency

That brings us to two important research/practice questions for each of the models.

1. What are the sources for inputs? That is, how will the policy maker enumerate the list of criteria? Assign relative importance weights? Establish an acceptable composite score? Determine the acceptable thresholds for these criteria?
2. Which modeling approach is more efficient and less biased? Particularly, for our decision: to reopen (or not) the economy and society.

There are three distinct sources for inputs. One, the outputs from structured consultations with all the stakeholders, including but not limited to public health officials, epidemiologists, infectious disease academic and research experts, businesses, data scientists, and model builders. These collective subjective inputs are empirically shown to be fairly accurate.

Table 2: Representative Listing of Models and Their Outputs[1]

	Forecast of Mortality and Required Hospital Resources	Forecast of Mortality
Based on both Infectious Theory and Data	Covid Act Now Covid 19 Simulator	Bass Model
Based largely on Computations (Data and/or Simulation) and/or Machine Learning	IHME Model Northeastern University Model	Iowa State Model Youyang GU Model

Perhaps the best approach is the Decision Support System (DSS) approach. In DSS, we combine the subjective recommendations from experts with the recommendations from analytical/statistical models. This approach is also called Re-analysis in Climate Change and Decision-Calculus in Business. Accordingly, we review here the analytical/statistical models briefly in the Appendix. John Little (1970) observed, "…a model should be simple, robust, easy to control, adaptive, as complete as possible, and easy to communicate with. Such a model, consisting of a set of numerical procedures for processing data and judgments to assist decision making, has been called a decision calculus. The model is meant to be a vehicle through which a manager can express his views about the operations under his control."

Non-compensatory decision making models are likely to be more efficient and less biased. They are more efficient for two reasons. One reason is that the non-compensatory decision making model requires lesser number of inputs (enumeration of criteria and setting threshold levels) than the compensatory decision making model, which requires more number of inputs (enumeration of criteria, assessing their relative importance weights, rating each criterion on performance, and setting a threshold composite score). Second reason is that non-compensatory model generates a large number of efficient heuristics (such as Elimination By Aspects) (See Hauser, Ding, & Gaskin, 2009[2]). The non-compensatory models are likely to be less biased, because there are smaller number of subjective inputs into the model.

For all these reasons, we recommend non-compensatory decision model for our instance: to re-open (or not) the economy and society.

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1 *Pleas see:*
https://covid19forecasthub.org/
https://projects.fivethirtyeight.com/covid-forecasts/?cid=rrpromo

2 *http://www.mit.edu/~hauser/Papers/Hauser_Ding_Gaskin_Sawtooth_Consideration_May_02_09.pdf*

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