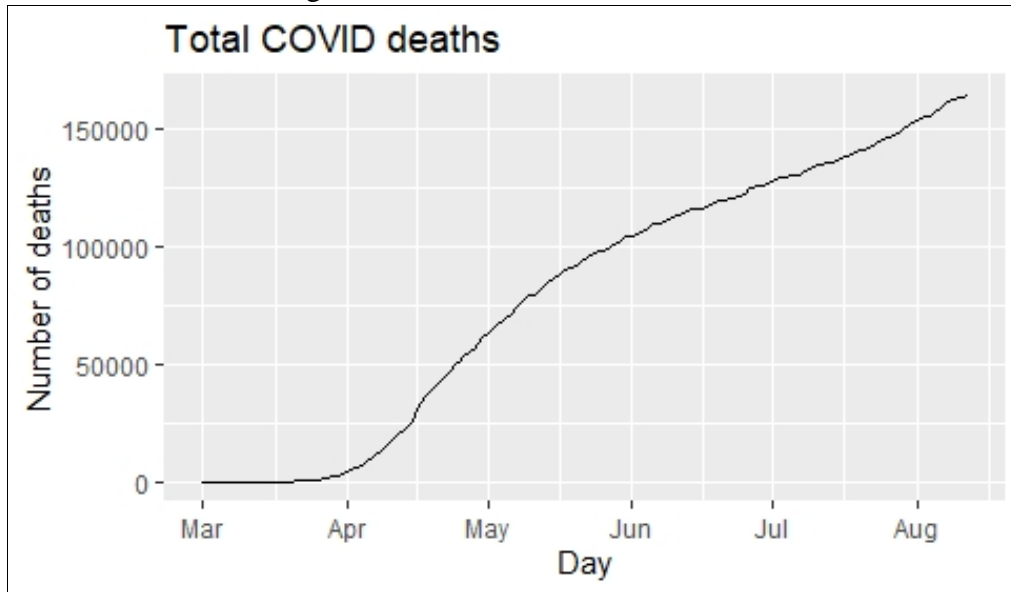


## ECON 5350 Midterm Exam – Fall 2020

The graph below shows total U.S. COVID deaths between March 1 and August 15, 2020. Use the graph to answer the following 5 questions and show all your work.

Figure 1. Total U.S. COVID Deaths



- 1) (20 pts) Consider the regression model:  $Deaths_t = \beta_1 + \beta_2 t + \beta_3 Cases_t + \beta_4 Tests_t + \varepsilon_t$ , where  $t = 1, \dots, T$  indexes days,  $Deaths_t$  is the total number of U.S. COVID deaths (graphed above),  $Cases_t$  is the total number of active cases, and  $Tests_t$  is the total number of COVID tests. Provide expected signs and interpretations of the coefficients. Go through each of the Classical assumptions and explain whether you expect it to hold and why.
- 2) (20 pts) Write the regression model in matrix form. Make sure to define each matrix and specify its dimension. Derive the least squares estimator,  $b$ , and the variance-covariance matrix of  $b$ .
- 3) (20 pts) Modify the model above to include a spline regression model with two kink points (i.e., knots). Then develop a test that the rate of change in total COVID deaths is constant throughout the sample period.
- 4) (20 pts) Use a simplified regression model,  $Deaths_t = \beta_1 + \beta_2 t + \varepsilon_t$ , to prove that the least squares estimator of  $\beta_2$  is unbiased and consistent.
- 5) (20 pts) The simplified model from part (4) is likely to introduce serial correlation. Show how the serial correlation is going to affect the variance-covariance of the errors,  $\Sigma$ . Given  $\Sigma$ , how will the OLS formula and the variance-covariance matrix of  $b$  change?