Assignment #3

MACS 30000, Dr. Evans
Due Wednesday, Nov. 24 at 11:30am

1. (This question still in progress.) **Simulation in Sociology, Moretti (2002) (3 points).** Read the paper, Moretti (2002), and write a one-to-two-page paper responding to the following questions.

   (a) The author discusses the role of simulation as a tool for exploring theory. She also highlights the importance of establishing "validity" of the simulative model of the theory. That is, validity is the degree to which the theoretical constructs and their computational implementation are representative of the real-world. What are some potential weaknesses in validity that the author describes with regard to multi-agent systems and cellular automata?

   (b) The author highlights "dynamic feedback" as a key characteristic that computer simulation is good at modeling. Dynamic feedback is where some initial stimulus changes behavior, and then that change in behavior creates new stimuli which in turn cause further behavioral change. Give an example of a model that the author cites from Sociology that exhibits this characteristic. Come up with an example of a research question on a political science topic where the underlying system exhibits dynamic feedback.

2. **Simulating your income (7 points).** Assume that all of you will graduate from MACSS program at the University of Chicago in June 2020. Your annual income from the time you graduate to the end of your life is generated by the following process,

$$\begin{aligned} \ln(inc_{2020}) &= \ln(inc_0) + \ln(\varepsilon_{2020}) \quad \text{and} \\ \ln(inc_t) &= (1-\rho)\Big[\ln(inc_0) + g(t-2020)\Big] + \rho\ln(inc_{t-1}) + \ln(\varepsilon_t) \\ &\quad \text{for} \quad 2021 \leq t \leq 2059 \end{aligned} \tag{1}$$

   where the variable inc_t is your annual income in year $t \geq 2020$, inc_0 is the average starting income ($t = 2018$) for a MACSS student, $\rho \in [0,1)$ reflects some positive dependence of today's income on last period's income, g is a long-run annual growth rate for your annual salary, and ε_t is an error term that is distributed lognormal $LN(0,\sigma)$ where σ is the standard deviation of the log of the error term. That is, $\ln(\varepsilon_t)$ is distributed normal $N(0,\sigma)$.

(a) (3 points) Let the standard deviation of your income process be $\sigma = 0.13$, let the persistence be $\rho = 0.4$, let the long-run growth rate of income be $g = 0.025$, and let average initial income be $inc_0 = \$80,000$. Assume you will work for 40 years after you graduate (2020 to 2059). Simulate 10,000 different realizations of your lifetime income. Do this by first drawing 10,000 sets of 40 normally distributed errors with mean 0 and standard deviation $\sigma = 0.13$. Then plug those into the income process (1) to simulate your lifetime income. Plot one of the lifetime income paths. Make sure your axes are correctly labeled and your plot has a title.

(b) (1 points) Plot a histogram with 50 bins of year $t = 2020$ initial income for each of the 10,000 simulations. What percent of your class will earn more than \$100,000 in the first year out of the program? What percent of the class will earn less than \$70,000? Is the distribution normally distributed (i.e., symmetric and bell curved)?

(c) (2 points) Suppose you graduate from the MACSS program with \$95,000 of zero-interest debt. You will use 10% of your annual salary after you graduate to pay off this loan. Plot the histogram of how many years it takes to pay off the loan in each of your 10,000 simulations. This histogram will only have as many bins as you have unique years in which people pay off their debt. In what percent of the simulations are you able to pay off the loan in 10 years (on or before $t = 2029$)?

(d) (1 points) Now suppose that the Chicago MACSS program becomes very well known in the next two years, and the skills you are learning are demanded more by employers. This increases the average starting salary to $inc_0 = \$90,000$, but the standard deviation in incomes increases also to $\sigma = 0.17$. Plot the new histogram of how many years it takes to pay off your loan of \$95,000 in your new 10,000 simulations with the new standard deviation and the new average initial salary. In what percent of the simulations are you able to pay off the loan in 10 years (on or before $t = 2029$)?

References

Moretti, Sabrina, "Computer Simulation in Sociology: What Contribution?," *Social Science Computer Review*, Spring 2002, *20* (1), 43–57.