**Introduction to Urban Science.**

**Assignment 4: Networked Models of Cities + Urban Scaling**

1. Read Bettencourt’s paper“The Origin of Scaling in Cities” **(**link Bettencourt\_Science\_2013.pdf**),** and/or 3.2.1 and 3.2.2 IUS book.
2. Explain briefly why "network effects" in cities depend on both population, *N*, and area, An,unlike in Metcalfe’s law (~100 words).
3. Using the mathematical relations from Table 1 in the paper (Table 3.3, p. 92 in IUS book):
4. What happens to the exponent for total social interactions if people stay at home and don’t interact? (what is *Hm*then?): does the city - as a network- exist? why (not)? [~100 words]
5. What happens to the same exponent, , if a city exists in higher spatial dimensions, D, (say in D=3, as in a future space station)? Does the exponent  get closer to 1 (no network effects)? Or further away than in D=2? What happens when the dimension of space, *D,*becomes very large (like in a “sci-fi city”) and you hold *Hm* fixed?  Why? [~150 words]
6. What is special about a city in 2 spatial dimensions (*D*=2), relative to one in 3D (*D*=3) or larger D? Discuss both socioeconomic outputs and dissipation costs in the two cases (2D vs 3D), and which has stronger network effects. Holding the baseline fixed, how much bigger (population) would a city have to be in 3D to realize the same level of socioeconomic outputs, , compared to 2D?  Answer with a general formula for the ratio of the population in the two cases in terms of the exponents and intercepts, if you can.

If not, pick an example, such as start with a city with one million people,  , and use the value of for D=2,  to write  . (You can set  to keep it simple). Then you want the value of  that gives you .  To compute , insert the exponent  for  and figure out what the population size  must be: is it bigger or smaller than  ?  Remember that everything becomes easier by taking logarithms [~150 words].

Submit your answers together in about 500 words or less.