**Introduction to Urban Science.**

**Assignment 9: Economic Growth, Development and Information**

**Either:**

**Qualitative Exercise:**Short Essay (<500 words)

1. Recall the concept of *rival* vs. *nonrival* quantities in economics (conserved versus not in other fields), IUS Ch 9. For a recent review from two distinguished economists read Jones and Romes (link JonesRomer2010.pdf), especially pages 230-232.
2. Explain why the distinction between *rival*vs*non-rival*goods is so important in (economic) growth. Specifically, explain why you need labor, capital and *knowledge* to produce anything (give an example, like baking a cake, but be more original if you can). Use your example to illustrate why labor and capital are rival quantities. Explain what kind of knowledge or ideas are *non-rival* and why. [~100 words]
3. Explain why -- with *better knowledge* but the *same* amount of labor and capital -- you can create greater value for your product (elaborate the example you chose above). [~100 words]
4. But *knowledge*is expensive to create: It takes years of time and effort, schools, universities and research institutions.  As we have seen, knowledge once produced can be copied - a cake recipe, a technology, or a scientific idea. This means that knowledge producers cannot be sure to recoup the fruits of their investment.  Explain why -- if knowledge is expensive to produce and can be copied and used by others—it may *not* be worth it to produce in terms of your example (compare costs minus benefits *to you*).  [~100 words].
5. Thus, in terms of economic cost-benefit analysis it is often wiser – from a *selfish* point of view – not to pay this cost and instead “free ride” by using knowledge produced by others. This leads to a [tragedy of the commons](https://en.wikipedia.org/wiki/Tragedy_of_the_commons) problem: Who will then produce knowledge?  Propose two different solutions to this conundrum - for example,  types of organizations, laws or government programs – to address this knowledge as a “public good” production problem. Please describe in each case who pays the costs of knowledge production, who benefits, and how virtuous cycles of economic growth may be created so that costs can be paid for and there is an incentive for knowledge production and application.  [~200 words].

**Or:**

**Quantitative Exercise:**Urban System Model of Economic Growth and Migration (Math Analysis, 1 page)

1. Consider a simple Urban System with only two cities, one large and one small, with populations . Take the total population of the urban system (nation) as fixed, equal to , so that   Express the fractions of population in each city,  in  terms of the parameter .
2. Now consider the GDP per capita of each city given by a superlinear scaling law, with   How much bigger is the GDP per capita of the larger city relative to the smaller one? Express the answer for the ratio  in terms of   What is this as a number with when ?
3. Now express the total GDP per capita of the system, , with , and  and the same for city 2, in terms of the variables :  Give an analytical expression for  in terms of these four variables.
4. Discuss if the GDP per capita increases or decreases when a) the pre-factor  increases exponentially over time (extensive growth); b) the total population  increases over time; c) The fraction of people in the larger city increases relative to the smaller one (increases).
5. For situation c) briefly discuss why urbanization (in the sense of moving people to larger cities, i.e. increasing ) contributes to (per capita GDP) national growth. What would happen if there were no superlinear effects ()?