

Instructions:

Keep your models as simple as possible while still telling a good story. Graphs are always appreciated. Be clear. Write neatly. If your answer cannot be read it will not be graded.

1. Environmental Kuznets Curve

What is the environmental Kuznets curve (EKC)? What are some reasons it may exist? What are some criticisms of the theory?

Many of you likely know more than your professor about the proposed shutdown of Germany's nuclear power. For those that do not, most of the German nuclear power infrastructure was built in the 1970s and 1980s; to my knowledge no new nuclear power plants have been constructed since the 1980s due to political pressure. In 2000, the government passed the Nuclear Exit Law, which called for the end of nuclear power use by 2020. Since passing the legislation, the popularity of the phase-out has fluctuated, and at times has seemed likely to be overturned. Despite gains in renewable energy, most of the nuclear power will be replaced by coal-powered power plants or imported from the nuclear power plants in France. Opponents of the phase-out worry about the increase in CO₂ emissions. Nuclear power is particularly important in Baden-Württemberg, where half of the state's energy is produced by nuclear. Proponents of the phase-out worry about the disposal of nuclear waste and the overall safety involved with operating a nuclear power plant, highlighted in 2007 by a fire at a nuclear power plant in Krummel. Between 2002 and 2006, the plant in Brunsbüttel had the highest number of safety incidents - 74 (Figure 2). The average lifespan of a nuclear power plant is 32 years, so many of these plants are getting old.

Assume that the phase-out occurs, and fifty years from now economists are trying to decide if this is evidence of the EKC's existence. The graph below shows growth rates for per capita GDP in Germany between 1980 and 2007. Briefly set up a model that could test the existence of the EKC. Explain all of your variables and your setup. What is the pollutant involved? Why might the EKC exist for this example? Why might it not exist? Comment on your model and approach in light criticisms of the EKC you listed above.

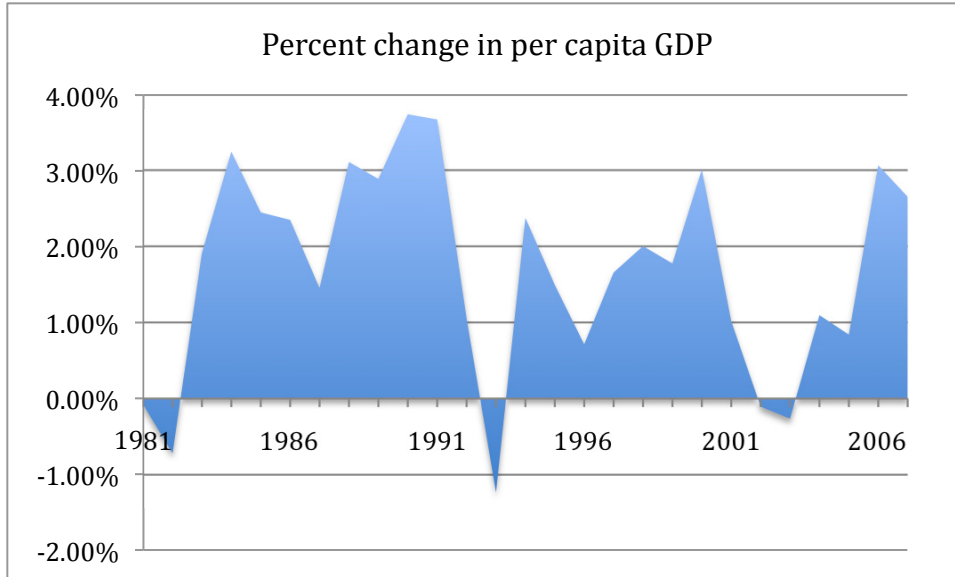


Figure 1. Growth in German GDP

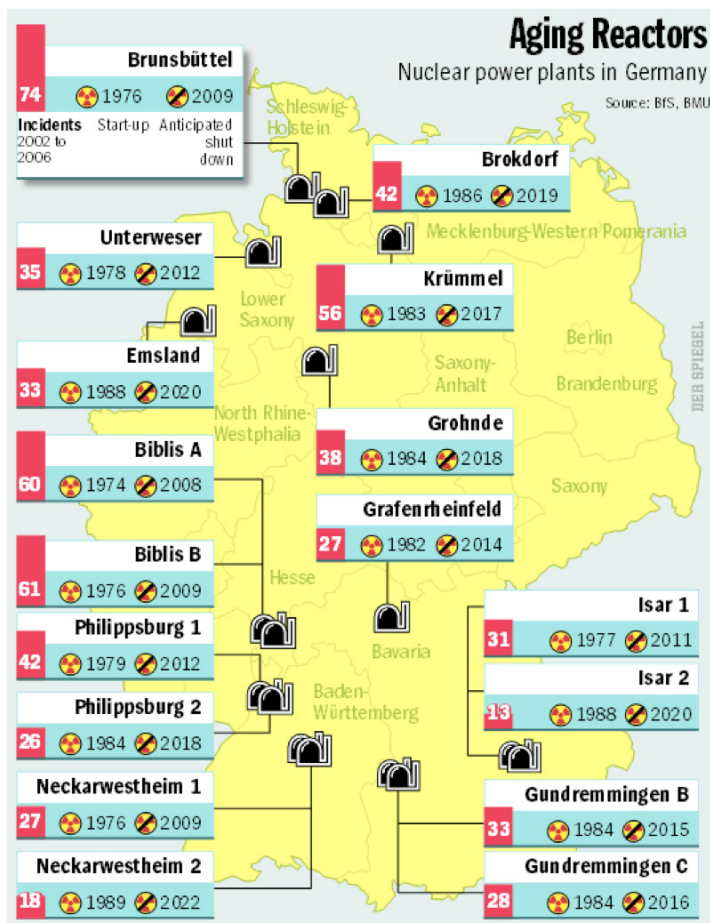


Figure 2. German nuclear power plants

2. Swine Flu Eradication

The first case of Influenza A (H1N1), aka the Swine Flu, ever reported was in April 2009. As of May 26, 2009 the World Health Organization reported 12,954 cases and 92 deaths worldwide (Figure 3). H1N1, like other forms of influenza, spread through human contact - sneezes, and coughs. Because the strain is new, people are not likely to have developed an immunity. There is currently no vaccine for H1N1.

Most infectious diseases, including the flu, can be described by a logistic growth function. Spread is fairly slow as contamination is limited to a few number of people. H1N1 is thought to have originated near a farm in Mexico, most likely staying within the local population for a while. Eventually an infected individual from that population came into contact with someone from outside, who then became infected and spread it within that person's community. Eventually those people infected others, rapidly spreading throughout the world thanks to the miracles of international air travel. We seem to be in the 'explosive' part of the growth function. Eventually, however, the exposed population will taper off. Remote communities are not likely to become infected and humans will likely develop immunity to the virus. Once this happens, further spread will be slow.

Develop a model for H1N1 and the possibility of its eradication. Let the total number of infections be F , with some upper limit of \bar{F} . Assume humans can engage in some sort of 'harvest' of the flu, for example, quarantining and treating infected individuals. The Smith (1975) model could serve as a good tool for building your model, though your model should include anything unique to the flu story. For example, how would you model human deaths in your model? What do your parameters mean? What causes the parameter values to change?

Using your model, discuss possibilities / policies for eradication. What parameters in your model determine the success of policy? Explain fully. Use graphs if appropriate. Compare your results for the swine flu with one that may be applied to HIV/AIDS eradication. How are the two illnesses similar with respect to the model? How are they different?

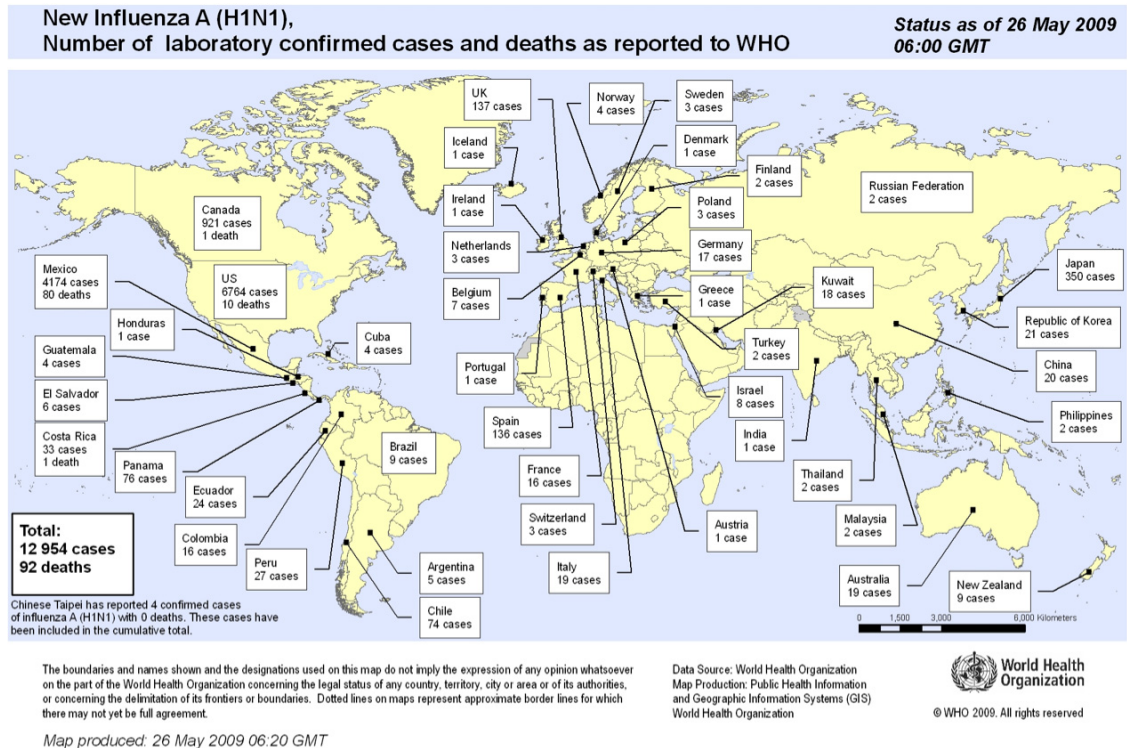


Figure 3. Global cases of swine flu

3. This questions asks to think a bit about the predator-prey model in the Easter Island paper. First, set up the basic model where a human population L harvest the resource stock S . Include births, deaths, and fertility in the human population dynamics. Include carrying capacity, rate of research growth, and harvest rate in the dynamics for your resource stock.

Now, consider the case of Saudi Arabia. The Kingdom of Saudi Arabia is the world's largest oil producer. About 45% of the country's gross domestic product is from oil. Oil makes up about 90% of the country's exports, and 75% of the government's revenues. It is fair to say that the Saudi economy is highly dependent on a single natural resource. It is also fairly obvious that the natural growth rate of oil is extremely slow. Analyze this using the predator-prey model you just developed. You can assume that oil begins at the 'natural carrying capacity' but for all practical purposes never grows (that is, $s=K$, and $r=0$). What are the implications of the model? What assumptions drive your results? There are some pretty significant differences between the Saudi Arabian story and those we usually explain with predator-prey models. What are these differences and what makes this model inappropriate for describing the Saudi Arabian story?

4. Yellowstone National Park was the first national park in the United States National Park system. It is an absolutely beautiful place filled with all sorts of large animals, including wolves and elk. The local elk herd is a primary source of food for

the wolves. Set up a basic predator-prey model where wolves are the predator and elk are the prey. Explain your variables and draw a phase diagram.

Now consider the effect of humans. A number of cattle ranchers settled in the Yellowstone area about 100 years ago. Prior to the arrival of ranchers, no cattle lived in the area. Turns out wolves also like to eat cattle, and the US government began a program of wolf extermination in the early 1900s. A US park ranger shot the last native Yellowstone wolf sometime in the 1920s. Add humans to your model and assume they harvest wolves and that wolves harvest cattle. What happens if wolves are completely removed from the park?

Up until 1995 there were no wolves in Yellowstone. New efforts, however, have reintroduced wolves to Yellowstone with great success. Reintroduce wolves into your model assuming wolves still hunt cattle but that people are no longer allowed to hunt wolves. Show what happens to cattle if people also hunt elk.

One final note about biodiversity in Yellowstone.. Since about the 1920s the park has lost about 95% of its Aspen forests, a major food source for elk, though they have recently began to recover. Is this surprising?

(For those interested, there are some real-world studies on the Google Groups page - Population Dynamics of JEH discusses the heard near Yellowstone, and Oklahoma Elk.)

5. Price of the manufacturing good in Krugman's North-South model is given by

$$P_M = \frac{2\mu L}{\frac{K_N}{c(K_N)} + \frac{K_S}{c(K_S)}}$$

where μ is the portion of income spent on manufacturing, L is amount of labor in each country, K_i is the amount of capital in country i , and $c(K_i)$ are the unit costs of manufacturing in country i . And profits (i.e., $P-c(K_i)$) are used to grow capital. Assume North originally has more capital. What does the model imply about growth rates of both countries? What are some strengths of the North-South model? What are some weakness? Give a real world example in which the model would be a good choice for analysis. Explain your choice.

Analyze the following policies:

- A fraction of North's profits are given South to invest in capital.
- A price floor is set, so that the price of manufacturing cannot fall below a specified level.
- Part of North's profits are used to lower the cost of manufacturing in South.

- d. Total profits (for both North and South) are taxed and used for government purchases of manufacturing. Thus μ is artificially high.
- e. A subsidy in agriculture, which is a substitute for manufacturing. The subsidy lowers the price of agriculture, which lowers μ .

6. Deforestation rates vary widely among developing countries, often even between neighboring countries, despite fairly uniform prices for exported timber, agriculture, and other natural resource-based goods. For example, Peru has an annual deforestation rate of 2.7 percent while Brazil has an annual deforestation rate of 8.3 percent. Other rates for neighboring countries include Columbia (1.5 percent annual loss), Venezuela (8.3 percent annual loss), Bolivia (6.5 percent annual loss), and Chile (0.5 percent annual loss).

Assume these countries follow the frontier expansion model described in Barbier's book. Welfare W is maximized over T periods of time, subject to production constraints (assume population growth is zero and total population equals 1). Following the notation in the book, this would be described mathematically by

$$W = \int_0^T [\beta \log c + \log z] e^{-\rho t} dt \quad \text{subject to} \quad \dot{k} = m(k) + a(n) - \omega k - q; \quad q = c + x; \quad z = px$$

and a country cannot harvest more than its total amount of forests $F_0 \geq \int_0^T n dt$.

The Hamiltonian for this problem is

$$H = [\beta \log(q - x) + \log(px)] e^{-\rho t} + \lambda [m(k) + a(n) - \omega k - q] - \mu n$$

Taking derivatives may help some of you answer this question, but it may not be necessary. The question is.. What does all of this mean? Specifically, answer the following questions:

- a) What does the discount rate ρ measure? What happens to deforestation rates if ρ is very high? What influences the discount rate?
- b) p is the relative price of domestic goods to imports, that is, the 'terms of trade.' Why does this matter for natural resource use? If p rises what will happen to deforestation rates?
- c) λ and μ are often referred to as the shadow prices for capital and frontier forests. What is a shadow price? What determines the value of the shadow price?
- d) ω is the depreciation rate of capital. What is a depreciation rate? How would it affect the rate of deforestation?
- e) If this model is correct, these variables should explain the differences in deforestation rates among the South American countries listed above. So why do Brazil, Venezuela, and Bolivia have high rates of deforestation and

Columbia and Chile have such low rates of deforestation? How would you explain countries where forests are increasing, where they are experiencing afforestation?

7. Tragedy of the Commons and Economic Governance

In class we discussed 'money on the table' and the incentive of others to enter the market until all gains of the resource are exhausted. This is the Tragedy of the Commons.

Crime can be thought of in much the same way. In the absence of clear secure property rights others forcefully take not only the 'money on the table' but the money in your pocket as well. Thus, the role of the police and government institutions is to protect individual property. Often when adequate government institutions do not exist, private institutions emerge. For example, after the fall of the Sicilian feudal system but before the modern Italian state had emerged, crime was very common. This period gave birth to the Sicilian Mafia, a private force that maintained security and civil obedience when no formal laws existed.

Imagine that you have data on land use and cattle grazing on lands in Sicily from the years 1850-1920, roughly the period the Sicilian Mafia rose to power. You would like to test whether the Mafia decreased the amount of cattle grazing over the open-access amount of cattle grazing during this time period.

State the hypothesis you would like to test. Set up a model that allows you to test your hypothesis. What are important variables in the model? What are the expected signs of coefficients on these parameters? Why?

8. Provision of Water - Many agencies providing aid to poor communities and developing nations focus on the provision of clean drinking water and sanitation infrastructure. According to one non-government relief organization, Helvetas, one person in six has no access to clean drinking water and a third of the world's population have no basic sanitation facilities.

Set up a model (do not solve) of water use and growth assuming water is a common public good subject to congestion. Show how you have modeled congestion. Using your model, how would you show the provision of water infrastructure (dams, pipes, irrigation canals, etc.) by international aid agencies? What does it imply about growth?

Many argue that the problem with water scarcity is that it is publicly provided - leading to congestion and the Tragedy of the Commons. Set up a small model of privately provided water (do not solve the model). What are some major differences between the two models? Areas of extreme water stress include conflict-ridden Central Africa. Is privatization of water likely to solve the problems in these areas? Why or why not?