ECO6143 Natural-Resource Economics
Final exam
December 10 2008
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Time allowed: 3 hours

This questionnaire has 4 pages.

1. (35 points) Financial crises and commodity prices

Figure 1 below shows the evolution of oil prices since 1970. The large increases during the 1970s are explained by the formation of cartels who cut down supplies. This *supply-side* explanation is rather uncontroversial.

The large increases since he late 1990s are typically explained by the increased demand originating from fast-growing emerging economies such as China and India. One problem with this *demand-side* explanation is that emerging economies started growing well before 1998. Moreover, it does not explain the jump in prices between 2007 and 2008 with the onset of a world recession. This has led some to seek alternative explanations for oil-price movements since 1998. Three observations that can be made from figure 1 include:

i) Oil prices began to grow *gradually* right after the Asian crisis of 1998.
ii) Oil prices jumped suddenly right after the subprime crisis during the summer of 2007.
iii) Oil prices have been free-falling since June 2008.

Try to explain this behavior in oil prices using the following story about asset prices and returns. Use the usual four-quadrant graphic for non-renewable resources. Assume zero extraction costs throughout.

> After the Asian crisis, investors the world over – including oil producing countries – began to gradually shift their investments into the USA because they had lost confidence in emerging economies. This capital influx led to a gradual fall in the returns investments in the USA as asset prices increased. In June 2007, the subprime crisis led to a sudden drop in asset returns and prices. By the summer of 2008, asset prices had dropped to such a low level that given the expected dividends, the long-run returns from assets in the USA was (suddenly?) considered high again.

2. (35 points) Rustling on the range

During the 1880s in the Western USA, ranchers were letting their cattle roam on large tracts of public land until ready to be sold. Cattle theft (or rustling) was thus a significant problem for ranchers. We would like to analyse the implications for pasture use and make some comparison with the problem of free access. (Note that sheep theft is still a problem today in England.)

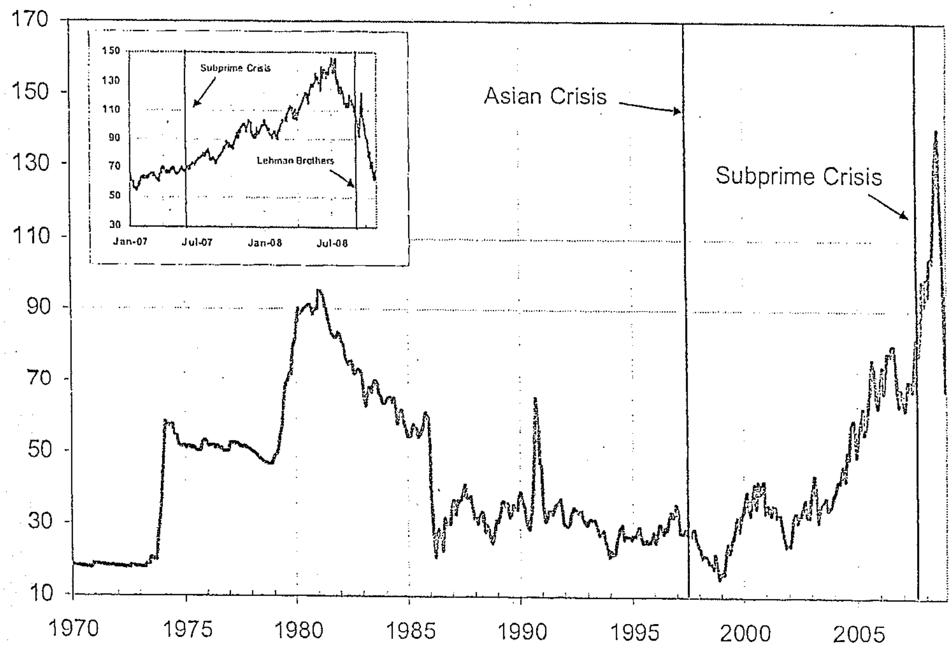

FIGURE 1. Real prices of oil (in Caballero et al. (2008))

Let z be the total number of cows sent on a given pasture land and chosen by the rancher. The constant unit cost of a cow is c. The output in terms of cowhide and meat is given by $f(z)$, with $f''(z) < 0$. Each unit of output sells for a constant price p. In the absence of theft, the rancher's net profits are thus $\pi = pf(z) - cz$.

a) Characterize the efficient number of cows to send on the pasture.

b) Assume that there are n ranchers accessing the same pasture and characterize the symmetrical free-access Nash equilibrium condition. Characterize the open access equilibrium when $n \to \infty$.

Let us now introduce rustlers (cattle thieves). To simplify, we assume that the total gain from rustling is independent of total rusting efforts but increases with the number of cows. Let $pg(z)$ denote the total loss from rustling with $g'(z) > 0$ and $g''(z) < 0$. The profits of the (unique) rancher are $\pi = pf(z) - cz - pg(z)$.

c) Solve for the rancher's profit maximizing choice of cows. Compare with the open access equilibrium. In terms of resource use, discuss the difference between imperfect property over exclusion from a pasture to imperfect property rights over the output.

3. Review question (30 points) Answer <u>one</u> of the following:

i) Population size, conflict and sustainable resource use

When a new track of land is being settled at some remote location, settlers have a choice between a sustainable use of the land or land mining. A sustainable use produces a constant flow of output y while mining produces an instantaneous gain of S. In both cases, the unit price of the output is equal to 1. Given an interest rate of r, we assume that a sustainable use of the land is *a priori* preferable with $y/r > S$.

The problem is that if the first settler to arrive decides for a sustainable use of the land, he must also protect it from other claimants. We assume that there are n claimants, including the first settler. If claimant i expends effort level x_i to appropriate the track of land, he has a probability

$$\frac{x_i}{\sum_{j=1}^{n} x_j}$$

of becoming the owner, in which case he benefits from the sustainable use of the land forever. Assuming that the unit cost of effort is c for all claimants, the *expected* value of the contest for a sustainable use for claimant i is thus

$$V_i = \frac{y}{r}\frac{x_i}{\sum_{j=1}^{n} x_j} - cx_i. \tag{1}$$

a) Assume for now that the first settler decides for a sustainable use of the land. He thus enters into a contest with $n-1$ other claimants. Derive the symmetrical Nash equilibrium level of effort x_i that will be expended by each contestant as a function of y, r, c and n.

b) Calculate the equilibrium value V_i^* for the first contestant of a sustainable use of the land.

c) Suppose that n is a measure of a country's population size. Compare V_i^* with S and argue that as the population size increases, it becomes less likely that settlers will opt for a sustainable use of land in new settlements.

ii) **Non-renewable Resource Extraction and the Right to Sell**

You are the happy owner of an oil deposit. However, somewhat sadly, you only live for two periods. This means that you have only two periods during which you can extract your oil, periods $t = 0$ and $t = 1$. Due to customary practice, you cannot resell your deposit to anyone else.

a) Let S_0 be the total initial quantity of oil barrels in the deposit. Each barrel fetches a fixed per-period price p_0 and p_1 on the market and the total cost of extraction per period is $c(R_t)$, where R_t denotes the quantity of barrels extracted at period t, with $c'(R_t) > 0$, $c''(R_t) > 0$. Using a discount factor of $\beta = 1/(1+r)$, write down the present-value profit maximizing problem and derive the corresponding optimal arbitrage condition between R_0 and R_1.

b) Calculate R_0 and R_1 assuming $S_0 = 500$, $p_0 = p_1 = 50$, $r = 10\%$, and $c(R_t) = R^2/20$. Calculate the marginal rent at each period. At what rate is it changing?

c) Do the same exercise as the previous assuming now $S_0 = 1200$. Interpret your result.

d) Suppose now that after you sadly leave us at the end of the period 1, life on Earth fortunately goes on, say for one more period to simplify. The government decides that due to intergenerational equity considerations, you are forced to leave 200 barrels of oil in the ground for the generation living during period $t = 2$, with $p_2 = 50$. Assuming $S_0 = 1200$ still, how would that affect your extraction rates R_0 and R_1?

e) The government considers amending customary law in order to allow you to resell your deposit. We would like to investigate whether the possibility of selling the oil deposit can affect your extraction choices R_0 and R_1, if at all. Analyze this question assuming $S_0 = 1200$ and $p_2 = 50$.

References

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas (2008) 'Financial crash, commodity prices and global imbalances.' Working Paper 14521, National Bureau of Economic Research, December