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Suggested (brief) answers, Examination

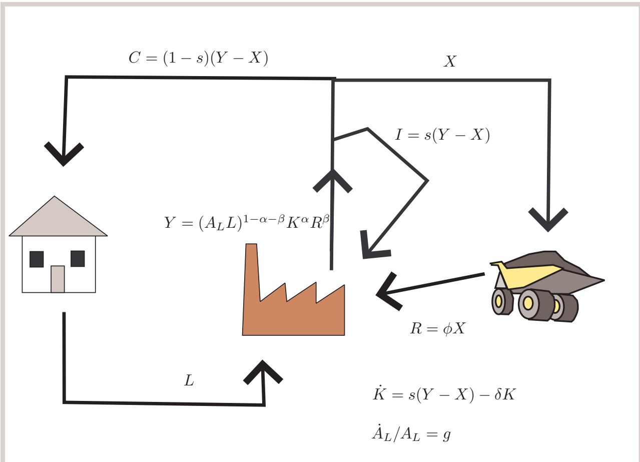
Economic Growth and Sustainable Development, NA0167.

1. (a) The resource price grows at the interest rate, i.e. $\dot{R}/R = \rho$. Explain why ...

   From the FOC you should find that $w_R R = \beta Y$, so (differentiating w.r.t. time) $\dot{w}_R/w_R + \dot{R}/R = \dot{Y}/Y$, hence $\dot{R}/R = \dot{Y}/Y - \rho$.

   (b) According to this model, resource prices should grow rapidly, whereas resource use should decline. But in fact resource prices are more-or-less constant in the long run (more precisely, there is no clear long-run trend) whereas resource use rises steeply, approximately tracking GDP.

   Assume a very large resource stock extracted using the final good with constant productivity. ((Alternatively, extract with labour, or labour and capital, and let labour productivity grow at equal rates in both sectors.)) Continue to assume a Cobb–Douglas final-good production function. Then we get a constant resource price and resource use tracking GDP growth.



   (c) The model has many weaknesses. First, it says nothing about what happens when (given exponential increase in resource use) resource stocks do start to run out. At this point, prices should rise and growth in resource use should slow or go into reverse, given the Cobb–Douglas function. If we had a finite (but very large) resource, costly to extract, then we would get a transition from constant prices to (in the limit) Hotelling-style price increases with declining resource use.

   But in reality if we ever got near that point, a bunch of other stuff would start happening. Like substitution to alternative inputs (especially if the resource in question is energy) or recycling (if the resource in question is for instance metals). And Solow's other mechanisms might be relevant ...

2. (a) i. Extraction costs are equal and the inputs are perfect substitutes, so if $X_C > X_D$ then coal will be used.

   ii. Since we have Leontief and coal is used we know that in equilibrium $Y = A_L L = E = A_C C$. The price of coal is 1, so expenditure on coal is C, and the answer is

$$\frac{C}{Y} = \frac{Y/A_C}{Y} = \frac{1}{A_C}.$$

   iii. The rest, so the fraction is $1 - 1/A_C$.

(b) The market allocation is 1 researcher on coal efficiency and 19 on labour efficiency, which implies that A_C is constant whereas A_L grows by 1.8 percent per year.

GDP and resource use will grow by 1.8 percent per year, and factor share will be constant.

(c) Given Pigou, the coal price doubles. But it's still cheaper than gas. The share of coal will double, there will be more investment in coal efficiency, which will (in the long run) double, bringing the growth rate of coal use down. But when coal efficiency has stopped growing, coal use will go back to tracking GDP.

(d) Society is patient, but tech investors are myopic: because coal has the bigger share, they keep investing on coal. We should, in addition, subsidize research on gas to make the researchers switch. As gas productivity increases, at some point the economy will switch to gas.

There is something to learn from this, but the model gives an exaggerated version of reality, since in reality the different productivities will not react in such a simple way to investments. Investment in gas may give big returns in the short run, but much less in the long run.

3. (a) i. $\alpha/(1-\alpha)$.

   ii. We know from (i) that $p_1 Y_1 = \alpha Y$, and $p_2 Y_2 = (1-\alpha) Y$. Use the second of these to show that

$$p_2 = (1-\alpha)\left(\frac{A_L L}{A_R R}\right)^{\alpha}.$$

   But $p_2 = w_r/A_R$, so we can rearrange to find

$$R = A_L L (1-\alpha)^{1/\alpha} A_R^{(1-\alpha)/\alpha} w_r^{-1/\alpha}.$$

   Finally note that we know that $w_r = 1$.

   iii. Raising A_R raises total factor productivity in the economy and causes an increase in energy consumption—backfire—whereas raising w_r has a strong negative effect on energy consumption, since it causes consumers to reduce their consumption of the energy-intensive good.

(b) The model is not very relevant when energy-intensive products have a much lower energy share than 100 percent, since substitution towards such products will not cause nearly such a large rebound effect, while rises in the price of energy will not have such a large negative effect on their consumption either. Explain this carefully for a really good answer.

To explain the rise in global energy use despite increases in A_R we need not only substitution effects of the type which are in the model above, but also income effects: as incomes rises, consumers choose more energy-intensive consumption types. Also, firms can substitute between capital, labour, and energy in the long run by investing in different types of capital which already exist, rather than developing new technology from scratch.

4. (a) The three mechanisms through which economies can adapt to future resource scarcity.

    - Invest in productivity of the resource.
    - Invest in productivity of an alternative resource.
    - Shift to production of goods which don't need the resource.

    Regarding fossil fuels.

    1. We can increase efficiency (better motors in cars, more efficient fridges, etc.).

    2. We can invest in boosting the efficiency of alternative power sources such as wind and solar. Since power from these sources is a good substitute for fossil power, if we could just make them cheaper they could take over more easily.

    3. We can stop consuming stuff like international air travel, private car travel, etc., and switch to less energy-intensive alternatives.

   (b) If we could fix all the other market failures in the global economy – such as knowledge spillovers, free-riding between countries, market power in the oil sector, etc. – then we would only need to fix the emissions price and everything would be cool. As long as we were also happy with the initial distribution of endowments then everything would be sorted.

    But when we have multiple unsolved externalities then we need to think carefully about what to do... and the strengths of the different mechanisms make a big difference. Give examples etc. for a really top answer.