Brief suggested answers

EGSD Examination, January 2018.

Note that longer answers may be required for full marks. For instance, it is important to show your working in calculation questions. And for discussion or essay questions my answers are intended as an outline.

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1. (a) i. Both models predict that Y and R should grow at equal rates (g in model 1, and a higher rate in model 2 because A_R is growing as well as A_L). Furthermore, the resource price is constant. However, in model 1 the resource price is zero whereas in model 2 it is $1/\phi$. Furthermore, in model 1 Y and R both drop to zero within finite time (i.e. they 'fall off a cliff').

   ii. Both models match the long-run data quite well, if we assume that we haven't fallen off the cliff 'yet'. They fail to match the short-run fluctuations in price that tend to be observed, but that is not a very serious weakness since the models are intended to address the long run. Furthermore, resource prices are of course not zero, so this is a weakness of model 1.

   iii. Model 1 gives a very poor explanation of the data, since it is clear that resources are not 'open access' but rather they are controlled by firms and nation-states which control extraction in order to make profits. Furthermore, extraction is costly rather than free. Hence the explanation for constant (zero) prices in the model does not hold. If we were to allow for private ownership of resources but continue to assume finite stocks and the same production function, then resource prices would rise exponentially, and the development of the economy would be very different. Model 2 does a pretty good job of explaining the data.

   (b) The long-run prediction of model 2 is that we can go on with business as usual for ever. However, this ignores the finiteness of resource stocks. If we impose finite resource stocks and make no other changes then in the long run we will have resource use approaching zero, resource prices rising steeply, and a significant brake on growth.

   Solow's mechanisms are that if R gets scarce, pushing w_R up, (i) firms can boost A_R through investment in R&D, (ii) firms can switch to substitute resources, and boost their productivity through investment in R&D, and (iii) consumers can switch to products of lower resource intensity.

   To capture the first two mechanisms we need to dump Cobb–Douglas and switch to (say) nested CES:

   $$Y = [(A_L L)^\epsilon + (A_R R)^\epsilon],$$
   $$\text{where} \qquad R = A_C C + A_D D$$

   and C and D are substitutable resources. To capture the third we need alternative Ys which differ in resource intensity, and which consumers can substitute between depend on price and income.

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2. (a) (i) $$\frac{w_L L_Y}{w_R R} = \left(\frac{A_L L_Y}{A_R R}\right)^{\epsilon}.$$

(ii) $$\frac{w_L L_Y}{w_R R} = \left(\frac{A_L / w_L}{A_R / w_R}\right)^{\epsilon/(1-\epsilon)}.$$

(iii) $$\frac{w_L L_Y}{w_R R} = \left(\frac{1}{\phi A_R}\right)^{\epsilon/(1-\epsilon)}.$$

(iii) $R = 900$ tons/year, $Y = 90$ hammers/year.

(b) i. We know that $z_l = 9$ and $z_r = 1$, from the factor shares. Putting these into the knowledge production functions we find that A_L grows by 1.6 percent whereas A_R is constant. Since A_R is constant, the factor shares are unchanged, and since the price of L_Y has gone up by 1.6 percent, the quantity of R must also rise by 1.6 percent. And the quantity of hammers also rises by 1.6 percent.

ii. We have a b.g.p. on which Y and R grow by 1.6 percent per year.

iii. The price of iron rises, its share increases, and investment in A_R increases, leading to growth in A_R. In the long run we would have a new b.g.p. with slightly slower growth in Y and much slower growth in R.

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3. (a) The consumption rates of many energy-intensive goods have increased steeply, much faster than GDP. Indeed, many of the most energy-intensive goods consumed today (such as passenger air travel) did not exist 100 years ago. The quantity of light produced and consumed has increased by a factor of several thousand in the richest economies over the last 200 years.

In theory these changes could be driven by fundamental changes in preferences, or (if we assume that underlying preferences are stable) by income effects (rich people like energy-intensive stuff) or substitution effects (people like cheaper stuff more than more expensive stuff). The income effect is of course linked to the fact that we have got richer over the last 200 years, whereas the substitution effect is linked to the fact that energy-intensive goods have got cheaper relative to other goods. This fall in price is due to a combination of the relatively constant price of energy inputs and the increase in energy-augmenting knowledge (i.e. energy efficiency).

Regarding evidence, this is tricky. How much have the prices of energy-intensive goods really fallen? And how do we demonstrate cause and effect? These are active areas of research. My personal view is that although substitution effects are surely relevant, income effects are also likely to be important.

(b) If consumers are price-sensitive then substitution effects may be strong for very energy-intensive goods. This means that increases in energy efficiency of such goods may lead to significant rebound. On the other hand, energy taxes would lead to major shifts in consumption patterns and hence reductions in energy use.

If income effects are strong (rich people like energy-intensive stuff) then energy taxes need to be very high to induce reductions in energy use. Then the key to CO_2 reductions is likely to be clean energy generation.

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4. (a) The marginal costs are input costs plus damages:

$$MC_1 = w_1 + \psi(A_L L)^{1-\alpha} R^\alpha;$$
$$MC_2 = w_1(1+\gamma).$$

The marginal benefits are identical for the two inputs:

$$MB_1 = MB_2 = \alpha Y/R.$$

They are perfect substitutes.

(b) i. The condition is

$$w_1\gamma/\psi = (A_L L)^{1-\alpha} R^\alpha,$$

and it implies that as A_L and L grow (also causing X_1 and hence R to grow) there comes a point when it is better to use input X_2 instead of X_1.

ii. If the economy is optimally regulated then R will initially be produced using X_1, and X_1 (and also pollution flows) will grow at a high rate (close to the overall growth rate). As GDP increases, pollution damages become significant, and brake the growth in X_1 somewhat (this could be through the use of a Pigovian tax, for instance). Then, when the condition above is fulfilled, the tax becomes so high that the economy switches totally to input X_2. (Alternatively, input X_1 is banned.)

(c) The model is relevant to the EKC, i.e. the environmental Kuznets curve hypothesis. The basic observation behind the EKC is that—for many pollutants, in many countries—pollution flows tend to first rise, and then fall. This is exactly what is predicted by the model.

Having stated this, you could develop your answer in 1000 different ways. For instance, you could discuss a particular case which supports the model (lead, asbestos, etc.), or you could discuss whether the model sheds light on the problem of carbon dioxide emissions, even though these are still rising in most countries, and the global aggregate is still rising steeply.