Brief suggested answers

EGSD Examination, February 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. Y and R should grow at equal rates (slightly higher than g because A_R is growing as well as A_L). Furthermore, the resource price is constant at $1/\phi$.

   ii. The model matches the long-run data quite well, although it fails to match the short-run fluctuations in price that tend to be observed, but that is not a very serious weakness since the model is intended to address the long run.

   iii. Model 2 does a pretty good job of explaining the data. Productivity increases, pushing the price down, but input prices also increase, pushing it 'back up'. Demand increases, driven by economic growth. It is of course very generalized.

   (b) 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:

$$
\begin{aligned}
& Y = [(A_L L)^\epsilon + (A_R R)^\epsilon]^{1/\epsilon}, \\
\text{where} \quad & R = A_C C + A_D D
\end{aligned}
$$

   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.

   But why would R get scarce? To capture this we would need to add of model of finite (or inhomogeneous) resource stocks.

   (c) Multiple products. Crucial for explaining why energy use tends to track GDP.

   Multiple resource inputs. Crucial for understanding the EKC, but endogenous productivity maybe not so crucial.

   Endogenous resource-augmenting knowledge. Not proven how important this is.

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2. (a)

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

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

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

$$
(iii) \quad R = 900 \text{ tons/year}, \quad Y = 90 \text{ hammers/year}.
$$

(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. Start by showing the DTC cannot explain the data if we accept that energy productivity of individual products has grown at least as fast as labour productivity. Then explain why this makes it unavoidable to conclude that it must be due to shifts in patterns of consumption over time towards energy-intensive goods. For instance from trains and busses to cars, and then to planes.

The key question for policy is then what has caused the shift. If it is a substitution effect (energy-intensive goods got cheaper) then an emissions tax would be effective in reversing the trend. But if it is an income effect (rich people like energy-intensive stuff) then taxes may need to be very high to reverse the trend directly, and the key is to induce a switch to cleaner technology.

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4. (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. 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.