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Examination – Brief answers

Economic Growth and Sustainable Development, NA0167.

1. (a) i. $\dot{w}_R/w_R = \rho$.
   ii. $w_R R = \beta Y$, so $\dot{w}_R/w_R + \dot{R}/R = \dot{Y}/T$, hence $\dot{R}/R = \dot{Y}/Y - \rho$.
   (b) Assume an infinite stock, and extraction using final goods, e.g. $R = \phi X_R$. (You could also have extraction using effective labour $A_X L_X$, where A_X grows with A_L.)
   (c) Add an alternative resource, more expensive to extract. And make the first resource either polluting or limited in quantity. If it's polluting (the easiest choice) show how this works out over time. Link to a specific empirical case.

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2. (a) You should get

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

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

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

   (b) You should get

$$\frac{w_L L_Y}{w_R R} = 19,$$

   so the ratio of factor costs is 19:1, i.e. 95 percent to labour, 5 percent to coal.

   950 i production, 50 in extraction.

   (c) 19 researchers on labour, 1 on coal. So we will have balanced growth at 1.9 percent per year, with coal extraction growing at the same rate.

   Not a good match to the real economy.

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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)

$$U = (A_L L)^{1-\alpha} X_1^\alpha (1 - \psi\phi X_1) - w_1 X_1.$$
$$\partial U/\partial X_1 = \alpha Y/X_1 - \psi\phi(A_L L)^{1-\alpha} X_1^\alpha - w_1.$$

Ignoring damages (which are small in this case) we have $w_1 = \alpha Y/X_1 = \alpha(A_L L/X_1)^{1-\alpha}$. Hence $X_1 = (\alpha/w_1)^{1/(1-\alpha)} A_L L$.

Ignoring extraction costs we instead have $\alpha Y/X_1 = \psi\phi(A_L L)^{1-\alpha} X_1^\alpha$, hence

$$X_1 = \frac{\alpha}{1+\alpha}\frac{1}{\psi\phi}.$$

Over time, emissions initially track growth, then gradually level off. Y grows initially at the growth rate of $A_L L$, and its growth rate slows very slightly when growth in coal inputs stops.

(b) Now the economy will follow the path described above up to a point, at which the planner will start substituting the emissions-free technology for coal, and coal use will gradually dwindle to zero.

As productivity increases, the cost of the damages from coal emissions increase. When the damages are equal to the difference between the input costs, the switch starts.

(c) Discuss cases where the model is a decent fit to reality, and cases where the model is too simple. What needs to be added to it in these cases?