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Examination, brief answers

Sustainable Development, NA0115.

Note that I merely sketch possible answers to the essay questions.

Rules

Answer 3 questions in total, out of 4 available. Each question is worth 20 points, and where a question is divided into parts, each part gives equal points. (If you answer 4, I will add up all your points and then multiply by 3/4.) As a broad guideline, there is one question related to each of the following topics.

1. Neoclassical growth theory, and the DHSS model.
2. Resource prices and quantities in neoclassical theory.
3. Directed technological change and sustainability.
4. Consumption, rebound, and sustainability.

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1. (a) See (for instance) lecture notes. Here are some key points to explain briefly. The production function is Leontief; capital is foregone consumption of final goods, and it depreciates; there is a fixed quantity of the resource; physical factor inputs K and R are augmented by the levels of factor-augmenting technology A_K and A_R.

   (b) The price of the resource $p_R = 0$.

      i. $Y_0 = 10,\ R_0 = 1;$
      $K_1 = 2,\ Y_1 = 20,\ R_1 = 2;$
      $K_2 = 4,\ Y_2 = 40,\ R_2 = 4;$
      Resource runs out in period 3.

      ii. $Y_0 = 10,\ R_0 = 1;$
      $K_1 = 2,\ Y_1 = 20,\ R_1 = 1;$
      $K_2 = 4,\ Y_2 = 40,\ R_2 = 1.33;$
      $K_3 = 8,\ Y_3 = 80,\ R_3 = 2;$
      $K_4 = 16,\ Y_4 = 160,\ R_4 = 3,2;$
      Resource runs out in period 4.

   (c) The model as it stands is not much use for explaining observations. Growth isn't based on capital accumulation, and rapid increases in A_R have been combined with rapid increases in R. And resources are not typically open access. A better model would replace capital by labour, and allow A_L and A_R to grow. Furthermore, we need products which differ in factor intensity. . .

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2. (a) i. Price $p_t = \frac{1}{1-\epsilon}(\lambda/\beta^t - \epsilon A)$, where $\beta = 1/(1+r)$ and r is the interest rate. Hence

$$\frac{p_{t+1}}{p_t} = \frac{1}{\beta}\frac{\lambda/\beta^t - \epsilon A\beta}{\lambda/\beta^t - \epsilon A}.$$

      ii. For $A = 0$ they are the same. For $A > 0$ the price rises faster given monopoly, for $A < 0$ the price rises more slowly given monopoly. For a faster rate of price rise the implication is a lower initial price and more rapid exhaustion; for a slower rate of price rise the reverse is true. (A graph may help you to explain this.)

   (b) One explanation could be that the Hotelling rent is very low, so the price is simply equal to extraction costs. Extraction costs are constant because technological progress (reducing costs) is balanced by the increasing wage. This balance is not a coincidence (explain).

   Alternative explanations include the idea that rising rent is cancelled out by decreasing extraction costs, or that the market is constantly surprised by new discoveries, hence the rent fails to rise. Neither of these explanations are satisfactory: If extraction costs were falling rapidly enough to cancel out increases in the Hotelling rent then they would soon hit zero, but prices are constant or falling over decades and even centuries; and it is not reasonable to suppose that the market is constantly surprised by the same pattern of events recurring decade after decade, century after century.

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3. (a) No it hasn't. Evidence we discussed in the course concerns lighting and motive power from combustion of fossil fuels. More generally, there are myriad uses to which we can put energy today compared to 300 years ago. Each of these uses implies a completely new stock of (product-specific) 'energy-augmenting knowledge'.

   (b) Theory. In the simple one-sector model with independent knowledge stocks, a rise in the price of energy should drive a rise in energy-augmenting knowledge. Conversely, when prices are constant such knowledge should fail to grow. But the evidence cited in part (a) leads us to reject this model.

   In a multi-sector model energy-augmenting knowledge may rise despite a failure of energy prices to rise, due to substitution towards energy-intensive products. If this substitution process is very strong then a rise in energy price may actually *reduce* the energy share, and lead to a *fall* in energy-augmenting investment.

   Evidence. Progress in energy-efficiency is not a stationary function of investment. In sectors such as lighting and transport there are well defined limits to energy efficiency: for instance, there is a limit to the amount of light (lumens) that can be generated from a given energy input, and there is a limit to the amount of motive power that can be generated from a given energy input. Furthermore, we are approaching these limits; LED lights and the latest internal combustion engines can be improved upon, but their efficiency cannot be doubled and doubled again. In the case of lighting, Fouquet claims that lighting efficiency increased by a factor of 1000 in the UK between 1800 and 2000. But the latest LED lights are at close to 50 percent of maximum efficiency, so only a factor of 2 remains available for the future.

   On the other hand, note that efficiency improvements in some other sectors—such as domestic heating—may well be limitless, and we may be able to approach a long-run situation in which homes can be held at the desired temperature with zero external energy inputs.

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4. (a) i. $p_l Y_L = \alpha Y$ and $p_R r Y_R = (1-\alpha)Y$.

ii. $w_l L = \alpha Y$ and $w_c C + w_d D = (1-\alpha)Y$.

iii.

$$\frac{w_c C}{w_d D} = \left(\frac{k_c C}{k_d D}\right)^{\epsilon} = \left(\frac{k_c/w_c}{k_d/w_d}\right)^{\epsilon/(1-\epsilon)}.$$

Further, note that $k_c = k_d$ so the equation can be simplified.

iv. C enters immediately and takes the share given in the answer to part (iii) above.

(b) In the model we have 100 percent rebound and no DTC, so the only option is to raise fossil-fuel prices relative to the price of clean energy (tax on fossil or subsidy to clean). If we allow some role for DTC but retain rebound, then there may be some role for instruments such as technology subsidies, but it is likely to be limited as long as the links between knowledge stocks are strong. (For instance, as long as both clean and dirty technologies build to a large extent on a common stock of general knowledge.)

All of these conclusions may be questioned. For instance, the data seems to suggest rebound, but the shifts to energy-intensive consumption observed could be a function more or *income* elasticity of demand than *price* elasticity. In that case it *could* be the case that rich economies will automatically decouple growth from energy demand in the future (without the need for energy price rises) due to the satiation of demand for energy-intensive goods. Maybe.

On the other hand, possibilities for increases in energy efficiency are running out in some sectors (lighting, possibly private transport), a tendency which may counteract any slackening in demand growth due to income effects.