Economic Growth and Sustainable Development, NA0167.

Examination, February 2021, suggested answer to question 3.

3. Consider the following model, which provides an explanation of why consumers may shift towards more energy-intensive goods over time.

There is an infinite series of products $Y_i$, and the production function for product $i$ is as follows:

$$Y_i = (1/2^{i-1}) \min\{A_L L_{Yi}, A_E E_i / 2^{i-1}\},$$

where $A$ is productivity, $L_Y$ is labour in final-good production, $E$ is the energy input, and $A_E$ is fixed. Consumers have lexicographic preferences such that they always prefer to consume the good with the highest $i$ that they can afford, given that they demand a minimum quantity.

Productivities $A_L$ and $A_E$ each grow at the constant exogenous rate $g$, and the initial factor share of energy is approximately 5 percent. All markets are competitive.

(a)   i. Find an expression for $E_i/L_{Yi}$, i.e. the ratio of energy to labour inputs in producing product $i$. Note that this is a measure of energy intensity.

ii. Compare the energy intensity of final goods $i$ and $i+1$.

iii. Explain why, as $A_L$ and $A_E$ grow, consumers shift to more energy-intensive goods.

iv. Explain the implications for the growth rate of energy use if the growth rates of $A_L$ and $A_E$ are equal.

v. What difference does it make if energy efficiency $A_E$ increases faster than $A_L$?

Swedes' spending on international flights rose rapidly between 1980 and 2018 (much more rapidly than GDP). The result was that energy use and carbon emissions from the sector grew rapidly, despite increasing efficiency of airplanes.

(b) Explain how the model above might be able to shed light on these observations, using the terms 'substitution effect' and 'income effect'. Discuss also alternative explanations and how they can be modelled and tested.

(a) (i) $E_i/L_{Yi} = (A_L/A_E)2^{i-1}$. Define this as $\eta_i$.
(ii) $\eta_{i+1}/\eta_i = 2$.
(iii) As $A_L$ and $A_E$ grow, consumers can afford goods with higher $i$, which they therefore choose (by assumption). These goods are also more energy-intensive.
(iv) If $L_{Yi}$ is constant then if (for instance) $A_L$ and $A_E$ are multiplied by 2 then $i$ goes up by 1, and $E$ is multiplied by 2. Hence $E$ tracks productivity growth (and also GDP if it is correctly measured).
(v) Assuming that $L_Y$ is constant then increases in $A_E$ will translate directly (proportionately) into reductions in energy use (no rebound). ((However in practice increases in $A_E$ will free up a little labour from the energy sector, so $L_Y$ may go up a little. This has not been specified in the question. But as long as the energy sector is only a small part of the economy, say 5 percent, then labour freed up from here and shifting into the final-good sector will not make much difference. So very little rebound.))

(b) We observe something related to what we see in the model, but just for one sector (transport). That is, with increasing productivity consumers shift into an energy-intensive sector (and thus out of other sectors with lower energy intensity).
In general, such a switch could be driven either by income effects or by substitution effects.

The model in the question focuses entirely on income effects. There is no substitution effect at all, since such effects are all about the extent to which households switch between alternative goods when the relative prices of the goods change. But in this model households have so-called lexicographic preferences and choose goods based entirely on what they can afford rather than relative prices.

We could also build a model with only substitution effects. *Explain briefly how such a model might be constructed.*

To test the models we can (for instance) measure consumer's income and price elasticities of demand for energy-intense goods, and also try to measure relevant price and income changes over time. High income elasticities and low price elasticities support the model in the question, whereas if income elasticities are low and price elasticities high then a model with only substitution effects might do the job.

In reality it is very hard to explain the data without income effects. There are of course substitution effects as well, the model presented is very simplified!