Further Examples Using CECANT

These two examples supplement the example given in the main article.

Example #1: Economy-wide Application

A Specific New Technology

Consider a somewhat fanciful but illustrative new technology. Suppose you are a government energy agency that has received an R&D funding proposal from a team of agricultural scientists who claim to be on the threshold of developing a new genetic modification that will allow a broad array of vegetables to ripen more uniformly and stay fresh for weeks, whether "on the vine" or after harvest, with little or no refrigeration or cooling to reach market. This technology, they believe, will also enable a whole new automated harvesting method that can replace human harvesters because judgments of the ripeness of the product are not required and crops can be harvested all at once instead of selectively over a period of weeks. The researchers are promoting this as a fuel-saving technology owing to the large amount of energy that will be saved by avoiding refrigerated storage. However, you realize that the implications for resource use are broader: the capital required for the automated harvesters is far less than the capital saved in refrigerated storehouse facilities; also, the labor needed for harvest will drop dramatically.

After some research, you develop the following estimate for a 4-factor technology vector of this technology using the procedure described in the User Guide and Appendix B:

$$\boldsymbol{\tau} = (1.0009, 1.006, 1.0012, 1.0)$$

The elements correspond to the factors capital (K), labor (L), fuel (F), and materials (M).

You have decided to use a Translog specification for the cost function to describe the economy, in particular the cost function measured by Berndt and Wood (1975).[1] Specified according to Appendix A, this cost function is [2]:

$$\mathbf{a} = \begin{bmatrix} .0564 & .2539 & .0442 & .6455 \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} .0254 & .0001 & -.0102 & -.0153 \\ .0001 & .0739 & -.0043 & -.0697 \\ -.0102 & -.0043 & .0214 & -.0068 \\ -.0153 & -.0697 & -.0068 & .0918 \end{bmatrix}$$

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[1] This measurement is somewhat outdated and ideally should be updated with more recent data using the procedure described in Appendix C. .

[2] Berndt and Wood evidently chose their reference year to be 1947. This is where we do the CECANT measurements.

Using CECANT, you find the vector of factor rebound elasticities (yellow cells) to be:

$$\boldsymbol{\eta}^F{}_{\boldsymbol{\tau}} = (\eta^F_{\tau_K}, \eta^F_{\tau_L}, \eta^F_{\tau_F}, \eta^F_{\tau_M}) = (0.484, 0.535, -0.524, 0.570)$$

The resulting multiplier on fuel use (orange cell) is:

$$F_{new} \big/ F_{old} = \tau_K{}^{\eta^F_{\tau_K}} \tau_L{}^{\eta^F_{\tau_L}} \tau_F{}^{\eta^F_{\tau_F}} \tau_M{}^{\eta^F_{\tau_M}} = 1.003$$

where the exponents of the technology vector elements are the rebound elasticities. (This expression follows from the definition of elasticity.)

Thus, you expect that successfully deploying this technology will lead to an *increase* in fuel use, economy-wide, of 0.3%. If your agency's goal is to fund R&D that reduces fuel use, you will reject the proposal. (Note, however, that this technology would actually increase economic welfare (the real output of the economy would increase)).

Note that it is possible in situations like this that the fuel/output ratio (roughly: the Energy/GDP ratio) will still decline even while fuel use increases in absolute terms,[3] indicating the unreliability of this popular *ex post* ratio as a measure of progress in restraining hydrocarbon emissions or as a tool for selecting technologies.

One further note: these results include the effect, not just of how a new technology can reduce the apparent cost of a factor and cause factor substitutions toward it, but of how the whole production possibilities space is increased. In calculating the rebounds, the tool takes account of the fact that total output is increased (in this example by 0.163%). Since economy-wide, income equals output, the results reflect how the new technology increases consumer income and so "drags up" factor demand. In this way, the "income effect" rebound researchers worry about is comprehended by the tool. [4]

The Total Technology Rebound (Standard Test #1) is $R_{\boldsymbol{\tau}} = 3.51$. This indicates that for every 1% increase in fuel efficiency, this technology creates a 3.51% increase in fuel use. Of course, being greater than unity this rebound measure indicates backfire.

General Results

Even without knowing the technology vector of a specific technology, you can infer how this economy will respond to new technologies in general and draw important policy conclusions. Using the tool, the resulting Technology Component Rebounds (Test #2) are:

$$R_{\tau_K} = 1.48 \quad R_{\tau_L} = 1.54 \quad R_{\tau_F} = 0.48 \quad R_{\tau_M} = 1.57$$

These results suggest that technologies that enhance factors other than fuel will backfire (R>1) causing the absolute level of fuel use to rise. Fuel-enhancing technologies will exhibit some rebound, but the effect nonetheless will be to reduce

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[3] See Saunders (2000).

[4] Output is increased at exactly the rate unit cost is decreased and income matches output (see discussion in the Assumptions section).

fuel use. From a carbon-reducing perspective therefore, fuel-efficiency technologies should be sought that are fuel-enhancing only, or that at least minimize the efficiency gains associated with other factors. This is a strong policy conclusion.

The Neutral Technology Response (Test #3) gives $R_{N\tau} = 2.07$. This says a technology that is neutral in the neoclassical sense will cause significant backfire in fuel use. A 1% increase in efficiency of the fuel component will lead to a 2.07% increase in fuel use, accompanied as it is by the efficiency gains in other factors. As a policy matter, this signals a warning regarding carbon emissions: technology trends (factor productivity gains) that look anything like neutral stand to exacerbate the problem.

The Fuel-Neutral Technology Multiplier (Test #4) gives $M_F^{FN} = 3.01$. This in effect says that a technology must generate about three times the efficiency gains for the fuel component as for the other factors if fuel use is not to increase.

This example is simply that: an example to illustrate the tool's use. Focus is not on the conclusions but on the tool, and on what questions it can capably explore. Certainly, it would be incautious to draw definitive conclusions from this example.

Example #2: Cross-country Comparison

Suppose you wish to compare a particular sector in one country with that of another country to observe any differences in response to fuel efficiency technologies. You decide to use Jorgenson and Fraumeni's cost function for Primary Metals for the United States, and Roy et al.'s (1999) cost functions for Iron and Steel and Aluminum for India.

The results are as follows:

Table 4: *Cross-country Comparison of Rebounds (Jorgenson & Fraumeni; Roy)*

Sector	R_{τ_K}	R_{τ_L}	R_{τ_F}	R_{τ_M}
India: Iron and Steel	1.48	1.57	0.18	0.41
India: Aluminum	2.24	0.72	-0.19	0.60
US: Primary Metals	1.24	1.76	1.11	2.42

Primary metals sectors in India seem to be much more responsive than their U.S. counterpart to technologies that improve fuel efficiency and materials efficiency. Globally speaking, it would appear advantageous to concentrate on technologies aimed at India in these sectors. Note also that in India fuel efficiency gains in Aluminum are "super-conserving," indicating that technologies targeted at this sector should be quite attractive.