

**Berndt E R & Wood D O.** Technology, prices, and the derived demand for energy.  
*Rev. Econ. Statist.* 57:259-68, 1975.  
[University of British Columbia, Vancouver, Canada]

Using a translog cost function, evidence is presented on separability and substitution possibilities among energy and nonenergy inputs in US manufacturing. Energy demand is price-responsive—the own price elasticity is  $-0.5$ ; energy and labor are substitutable while energy and capital are complements. Further, of all the possible input separability combinations, only the existence of an energy-capital subfunction is supported by the data. [The *SCI*® and the *SSCI*® indicate that this paper has been cited in over 270 publications, making it the most-cited paper from this journal.]

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Our research collaboration on energy demand began in 1972 when we were both employed in the US Office of Emergency Preparedness (OEP) of the Executive Office of the President. General George Lincoln, then OEP's director and the Nixon Administration's most prescient energy policy expert, anticipated the emergence of energy as a critical international policy issue. Under the guise of conducting a narrowly conceived White House Domestic Council energy conservation study, he directed his research staff to begin developing data and undertaking studies to increase knowledge of the determinants of energy demand and the role of energy in productivity, economic growth, and international competitiveness. Our research was a modest part of that shadow effort, drawing importantly on the US interindustry energy accounts constructed by Jack Faucett Associates.<sup>1</sup>

Our *Review of Economics and Statistics* paper has been widely cited for two empirical results and because the database became an

"economic laboratory" for subsequent energy cost and production studies. The first empirical result was that energy and capital are complements, that is, that an increase in the price of energy reduces the demand for both energy and capital. This result was controversial for two reasons. First, while economic production and cost theory recognizes the possibility of input factor complementarity, our study was one of the first employing a functional form that could reveal such a relationship in the data. Hence, this empirical finding was unfamiliar to economists. Second, energy-capital complementarity seemed to contradict engineering process ideas of the relation between these inputs, namely, that increases in energy efficiency are attained only by increases in physical capital inputs. The latter issue concerned us as well, and in 1979 we developed a mathematical and graphical reconciliation of the economic and engineering notions of the energy-capital relationship.<sup>2</sup>

The second major empirical result concerned separability tests among all possible input combinations. Our study found evidence that only the energy-capital input combination was separable from other inputs. This has two implications. First, it suggests that the aggregate of energy and capital can be interpreted as a measure of utilized capital services, a result that forms the basis for our more recent work in this area.<sup>2,3</sup> Second, and of more general interest, this result calls into question the reliability of investment and factor demand studies for US manufacturing based on the value-added specification that capital and labor are separable from the intermediate inputs of energy and materials.

Finally, there has been an unanticipated legacy from this paper. We note with some pride that our database has been widely used by other scholars, both to replicate the results and to investigate other functional forms and model specifications. This welcome result was achieved in part by having an editor who permitted us to publish the data set rather than resorting to the familiar footnote, "the data are available upon request." There is a lesson here regarding scholarship, and the strategy to follow in writing a *Citation Classic*.

Recent work in this field has been carried out by J.V. Greenman and L.P. Drollas.<sup>4</sup>

1. Jack Faucett Associates. *Data development for the I-O energy model: final report.* Chevy Chase, MD: Jack Faucett Associates, May 1973.
2. Berndt E R & Wood D O. Engineering and econometric interpretations of energy-capital complementarity. *Amer. Econ. Rev.* 69:342-54, 1979. (Cited 105 times.)
3. Berndt E R. Aggregate energy, efficiency, and productivity measurement. *Annu. Rev. Energ.* 3:225-73, 1978.
4. Greenman J V & Drollas L P. The price of energy and factor substitution in the US economy. *Energ. Econ.* 9:159-66, 1987.

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