

# Good Modeling of Bad Outputs: A System Approach

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## Abstract

In this paper we consider a modeling approach that accommodates multiple outputs (some of which can be unintended/undesirable/bad) and multiple inputs, some of which can be pollution generating (bad). Technology for the production of good outputs is specified in terms of a transformation (distance) function in which only good outputs and good inputs appear as arguments. Bad (undesirable) outputs are viewed as ‘by-products’ of good outputs and pollution generating inputs. Technology/technologies for the production of bad outputs is/are separated from the technology for good outputs. By separating the two, we can separately estimate technical and environmental efficiencies, defined in terms of the technologies for the production of good and bad outputs, respectively. Additionally, we address endogeneity of inputs in terms of cost minimizing behavior of producers. Since the good output (electricity in our application) is determined by exogenous demand, we treat it as exogenous which justifies our use of input distance function and input-oriented technical inefficiency. We use the Bayesian MCMC technique to estimate both types of technologies and inefficiencies. We estimate shadow prices of bad outputs in terms of increase in cost (via increase in the use of inputs). Furthermore, shadow prices of good outputs in terms of direct cost to the producer and indirect cost to the society (in terms of increased production of bad outputs), are also calculated.

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