Is There Really Granger Causality Between Energy Use and Output?

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The nature of the relationship between energy use and economic growth is central to debates about climate policy, energy security, and the effects of energy price shocks on the economy. To study this relationship, a very large literature consisting of hundreds of academic papers uses Granger causality tests to investigate whether changes in energy use cause changes in economic output or vice versa. Granger causality, named after Nobel Laureate in economics, Clive Granger, is based on the idea that a variable will only help forecast another variable given all other relevant information if in fact it has a causal effect on that variable.

Yet despite recent attempts to review and organize this research, this literature is still very inconclusive. We find that about 40% of tests find a statistically significant causal relationship between energy and growth, irrespective of the direction of causality tested. This is much larger than the number of positive results that would be expected by chance under classical statistical assumptions (5%), but it is still hardly overwhelming evidence. Furthermore, results seem to be affected by the samples of data used, which other variables researchers control for in their analysis etc.

Our goal is to determine whether there is a genuine causal relation between energy use and economic output or whether the large number of apparently statistically significant results

is due to various biases. First, it is well known that statistically significant results are more likely to be published by journals and so researchers may discard or not bother submitting insignificant results for publication. If researchers do submit such insignificant results for publication they are likely to be rejected by journal referees and editors. Second, because the Granger causality testing framework is quite flexible, authors can actively search for model specifications that either confirm their favored hypotheses or simply produce statistically significant results that increase their probability of getting published. Lastly, our paper also calls attention to the problem of increased false positives when short time series are used. Some model fitting criteria select models that spuriously find a causal relationship between the variables in smaller samples of data. As a result of these three issues, the published literature may be strongly biased so that it actually has little to say about the causal link between energy use and economic output.

We synthesize the literature using meta-analysis – a statistical approach that aggregates the statistical results of many existing, individual studies. Meta-analysis enables us to search for genuine causal effects in the empirical energy-growth literature while controlling for a variety of biases that may distort the published findings. The principal idea behind this approach to the meta-analysis of empirical studies is that if there is a genuine relationship present in the data then, other things constant, studies with larger samples should have more statistically significant results. If this is not the case, then no genuine effect is present. We adjust the standard methods used in economics to detect genuine effects for the special features of Granger causality tests.

We collected 500 papers on the topic and selected a sample of more than 1,000 test statistics from a subset of 72 papers for statistical analysis. This subset of articles – selected using transparent and well-documented criteria - were sufficiently comparable to each other,

provided sufficient information for our analysis, and met minimum standards of econometric techniques.

The results of our meta-analysis suggest that the majority of statistically significant results in the literature are due to the types of biases described above. Our results, however, reveal that studies that control for changes in energy prices find a genuine causal relation from economic output to energy use when energy prices are controlled for. These models identify an energy demand function where both energy prices and income have an effect on energy use.

Our findings point to the importance of embedding the empirical analysis of energy use and economic output into an appropriate theoretical framework. More theoretically guided studies may help to reduce the large amount of biased results and to set up empirical research designs that provide for valid inference. Researchers should also be wary of relying on results from studies using very short time series. The methods we develop in the paper should also be of use in other fields where Granger causality testing has been important, including monetary policy, finance and economic development, and statistical climate modeling.