Decomposition analysis when there are common factorial effects: how to reduce its size?

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In many decompositions of an aggregate change in a variable into several factors there are one or more factors common to all research units (sectors, countries etc.) In our toy model, borrowed from Chung and Rhee (2001) (C&R), of the sectoral decomposition of carbon dioxide emissions the factor â€˜size of the economyâ€™, measured by GDP, is common to all sectors. It is straightforward to show that in the multiplicative four-factor decomposition GDP can be factorized out so that the decomposition is reduced to a three-factor one. In this paper we consider the additive decomposition of the C&R model and - using a novel trick - answer the research question: â€˜Is it possible to reduce the additive four-factor decomposition to a three-factor one?â€™ It is a multi-step procedure using at each step the Bennet decomposition which, by collecting duplicates, reduces the computation of the average of n! elementary decompositions to a weighted average of 2^(n-1) combinations. In the empirical part we apply it to the two datasets provided by C&R: (i) seven sectors in which changes-in-sign are present and (ii) four sectors without negatives.
This multi-step procedure allows for a considerable reduction in computational burden. As example we show that in the framework of the six- factor model with two common factorial effects used in Lan et al. (2016) an additive decomposition can be performed using the weighted average of 2^3 = 8 combinations instead of computing the average of 6! = 720 elementary decompositions.
References:
Chung, H.S. and H.C. Rhee (2001), A residual-free decomposition of the sources of carbon dioxide emissions: a case for the Korean industries, Energy 26, 15-30.
Lan, J., A. Malik, M. Lenzen, D. McBain and K. Kanemoto (2016), A structural decomposition analysis of global energy footprints, Applied Energy 163, 436â€“451.