Electronic Supplementary Material

Decomposition analysis applied to energy and emissions: A literature review

Hui WANG (✉)

School of Economics and Management, China University of Petroleum, Qingdao 266580, China; Institute for Energy Economics and Policy, China University of Petroleum, Qingdao 266580, China

E-mail: wh@upc.edu.cn

Yafei YANG

School of Economics and Management, China University of Petroleum, Qingdao 266580, China

Appendix A. Representative forms of decomposition models and general formulae for common decomposition methods

Category	Decomposition forms	Method	Formulae of the effect of the *n*th factor
Laspeyres-linked	Additive[a]	Shapley/Sun; Additive D&L	$\Delta V_{un} = \frac{1}{2}[(\sum_{i=1}^{n} u_{1i}^{0} \cdot u_{2i}^{0} \cdot \ldots \cdot u_{ni}^{T} - \sum_{i=1}^{n} u_{1i}^{0} \cdot u_{2i}^{0} \cdot \ldots \cdot u_{ni}^{0}) + (\sum_{i=1}^{n} u_{1i}^{T} \cdot u_{2i}^{T} \cdot \ldots \cdot u_{ni}^{T} - \sum_{i=1}^{n} u_{1i}^{T} \cdot u_{2i}^{T} \cdot \ldots \cdot u_{ni}^{0})]$
	Multiplicative[b]	Generalized fisher index; Multiplicative D&L	$D_{un} = (\frac{\sum_{i=1}^{n} u_{1i}^{0} \cdot u_{2i}^{0} \cdot \ldots \cdot u_{ni}^{T}}{\sum_{i=1}^{n} u_{1i}^{0} \cdot u_{2i}^{0} \cdot \ldots \cdot u_{ni}^{0}} \frac{\sum_{i=1}^{n} u_{1i}^{T} \cdot u_{2i}^{T} \cdot \ldots \cdot u_{ni}^{T}}{\sum_{i=1}^{n} u_{1i}^{T} \cdot u_{2i}^{T} \cdot \ldots \cdot u_{ni}^{0}})^{1/2}$
Divisia-linked[c]	Additive	LMDI-I	$\Delta V_{un} = \sum_{i=1}^{n} L\left(V_i^T, V_i^0\right) \ln\left(\frac{u_{ni}^T}{u_{ni}^0}\right)$
		LMDI-II	$\Delta V_{un} = \sum_{i=1}^{n} \frac{L\left(V_i^T / V^T, V_i^0 / V^0\right)}{\sum_{i=1}^{n} L\left(V_i^T / V^T, V_i^0 / V^0\right)} L\left(V^T, V^0\right) \ln\left(\frac{u_{ni}^T}{u_{ni}^0}\right)$
	Multiplicative	LMDI-I	$D_{un} = \exp\ (\sum_{i=1}^{n} \frac{L\left(V_i^T, V_i^0\right)}{L\left(V^T, V^0\right)} \ln\left(\frac{u_{ni}^T}{u_{ni}^0}\right))$
		LMDI-II	$D_{un} = \exp\ (\sum_{i=1}^{n} \frac{L\left(V_i^T / V^T, V_i^0 / V^0\right)}{\sum_{i=1}^{n} L\left(V_i^T / V^T, V_i^0 / V^0\right)} \ln\left(\frac{u_{ni}^T}{u_{ni}^0}\right))$

Note:

The formulae for the aggregate V and sub-aggregate V_i: $V^T = \sum_{i=1}^{n} u_{1i}^T \cdot u_{2i}^T \cdot \ldots \cdot u_{ni}^T,\ V^0 = \sum_{i=1}^{n} u_{1i}^0 \cdot u_{2i}^0 \cdot \ldots \cdot u_{ni}^0$

$V_i^T = u_{1i}^T \cdot u_{2i}^T \cdot \ldots \cdot u_{ni}^T,\ V_i^0 = u_{1i}^0 \cdot u_{2i}^0 \cdot \ldots \cdot u_{ni}^0$

a: Additive decomposition: $\Delta V_{tot} = V^T - V^0 = \Delta V_{u1} + \Delta V_{u2} + \cdots + \Delta V_{un}$

b: Multiplicative decomposition: $D_{tot} = \frac{V^T}{V^0} = D_{u1} \cdot D_{u2} \cdot \ldots \cdot D_{un}$

c: The operator $L(\cdot,\cdot)$ in LMDI is defined as: $L(a,b) = \begin{cases} \frac{a-b}{\ln a - \ln b}, & if\ a \neq b \\ a, & if\ a = b \end{cases}$

Appendix B. Lists of the top 50 articles with the largest LCS value

Category	ID in Fig. 2	Title	Authors	Journal
IDA & SDA	103 Wang H, 2017	Assessing drivers of economy-wide energy use and emissions: IDA versus SDA	Wang H, Ang BW, Su B	*Energy Policy*
IDA	64 Mousavi B, 2017	Driving forces of Iran's CO_2 emissions from energy consumption: An LMDI decomposition approach	Mousavi B, Lopez NSA, Biona JBM, Chiu ASF, Blesl M	*Applied Energy*
	62 Shao S, 2016	Using an extended LMDI model to explore techno-economic drivers of energy-related industrial CO_2 emission changes: A case study for Shanghai (China)	Shao S, Yang LL, Gan CH, Cao JH, Geng Y, et al.	*Renewable and Sustainable Energy Reviews*
	55 Zhang W, 2016	Decomposition of intensity of energy-related CO_2 emission in Chinese provinces using the LMDI method	Zhang W, Li K, Zhou DQ, Zhang WR, Gao H	*Energy Policy*
	54 Zhao XR, 2016	Decoupling CO_2 emissions and industrial growth in China over 1993-2013: The role of investment	Zhao XR, Zhang X, Shao S	*Energy Economics*
	50 Zhao X, 2017	Decoupling economic growth from carbon dioxide emissions in China: A sectoral factor decomposition analysis	Zhao X, Zhang X, Li N, Shao S, Geng Y	*Journal of Cleaner Production*
	49 Ang BW, 2016	Carbon emission intensity in electricity production: A global analysis	Ang BW, Su B	*Energy Policy*
	44 Ang BW, 2016	A spatial-temporal decomposition approach to performance assessment in energy and emissions	Ang BW, Su B, Wang H	*Energy Economics*
	40 Zhou X, 2017	A comparative study on decoupling relationship and influence factors between China's regional economic development and industrial energy-related carbon emissions	Zhou X, Zhang M, Zhou MH, Zhou M	*Journal of Cleaner Production*
	40 Sumabat AK, 2016	Decomposition analysis of Philippine CO_2 emissions from fuel combustion and electricity generation	Sumabat AK, Lopez NS, Yu KD, Hao H, Li R, et al.	*Applied Energy*
	40 Karmellos M, 2016	A decomposition analysis of the driving factors of CO_2 (carbon dioxide) emissions from the power sector in the European Union countries	Karmellos M, Kopidou D, Diakoulaki D	*Energy*

39 Guan DB, 2018	Structural decline in China's CO_2 emissions through transitions in industry and energy systems	Guan DB, Meng J, Reiner DM, Zhang N, Shan YL, et al.	*Nature Geoscience*
37 Li AJ, 2017	Decomposition analysis of factors affecting carbon dioxide emissions across provinces in China	Li AJ, Zhang AZ, Zhou YX, Yao X	*Journal of Cleaner Production*
37 Achour H, 2016	Decomposing the influencing factors of energy consumption in Tunisian transportation sector using the LMDI method	Achour H, Belloumi M	*Transport Policy*
35 Zhang X, 2017	How to achieve the 2030 CO_2 emission-reduction targets for China's industrial sector: Retrospective decomposition and prospective trajectories	Zhang X, Zhao XR, Jiang ZJ, Shao S	*Global Environmental Change*
35 Shao S, 2016	Uncovering driving factors of carbon emissions from China's mining sector	Shao S, Liu JH, Geng Y, Miao Z, Yang YC	*Applied Energy*
32 Xu SC, 2016	Factors that influence carbon emissions due to energy consumption based on different stages and sectors in China	Xu SC, He ZX, Long RY, Chen H	*Journal of Cleaner Production*
32 Li H, 2017	Identifying the driving forces of national and regional CO_2 emissions in China: Based on temporal and spatial decomposition analysis models	Li H, Zhao YH, Qiao XY, Liu Y, Cao Y, et al.	*Energy Economics*
32 Chen JD, 2018	Decomposition and decoupling analysis of CO_2 emissions in OECD	Chen JD, Wang P, Cui LB, Huang S, Song ML	*Applied Energy*
31 Jiang JJ, 2017	Provincial-level carbon emission drivers and emission reduction strategies in China: Combining multi-layer LMDI decomposition with hierarchical clustering	Jiang JJ, Ye B, Xie DJ, Tang J	*Journal of Cleaner Production*
30 Xu SC, 2016	Comparative analysis of the regional contributions to carbon emissions in China	Xu SC, He ZX, Long RY, Chen H, Han HM, et al.	*Journal of Cleaner Production*
30 Wang Q, 2016	Journey to burning half of global coal: Trajectory and drivers of China's coal use	Wang Q, Li RR	*Renewable and Sustainable Energy Reviews*
30 Chong CH, 2017	LMDI decomposition of energy consumption in Guangdong Province, China, based on an energy allocation diagram	Chong CH, Liu P, Ma LW, Li Z, Ni WD, et al.	*Energy*

	29 Xie PJ, 2019	An analysis of the decoupling relationship between CO_2 emission in power industry and GDP in China based on LMDI method	Xie PJ, Gao SS, Sun FH	*Journal of Cleaner Production*
	29 Fan FY, 2016	Decomposition analysis of energy-related carbon emissions from the transportation sector in Beijing	Fan FY, Lei YL	*Transportation Research Part D: Transport and Environment*
	28 Zheng JL, 2019	Regional development and carbon emissions in China	Zheng JL, Mi ZF, Coffman D, Milcheva S, Shan YL, et al.	*Energy Economics*
	27 Wang QW, 2016	Decoupling and attribution analysis of industrial carbon emissions in Taiwan	Wang QW, Hang Y, Zhou P, Wang YZ	*Energy*
	27 Roinioti A, 2017	The decomposition of CO_2 emissions from energy use in Greece before and during the economic crisis and their decoupling from economic growth	Roinioti A, Koroneos C	*Renewable and Sustainable Energy Reviews*
	26 Xu SC, 2017	Analysis of regional contributions to the national carbon intensity in China in different Five Year Plan periods	Xu SC, Han HM, Zhang WW, Zhang QQ, Long RY, et al.	*Journal of Cleaner Production*
	26 Lyu W, 2016	Driving forces of Chinese primary air pollution emissions: An index decomposition analysis	Lyu W, Li Y, Guan DB, Zhao HY, Zhang Q, et al.	*Journal of Cleaner Production*
SDA	74 Lan J, 2016	A structural decomposition analysis of global energy footprints	Lan J, Malik A, Lenzen M, McBain D, Kanemoto K	*Applied Energy*
	71 Su B, 2017	Multiplicative structural decomposition analysis of aggregate embodied energy and emission intensities	Su B, Ang BW	*Energy Economics*
	69 Su B, 2016	Multi-region comparisons of emission performance: The structural decomposition analysis approach	Su B, Ang BW	*Ecological Indicators*
	68 Cansino JM, 2016	Main drivers of changes in CO_2 emissions in the Spanish economy: A structural decomposition analysis	Cansino JM, Roman R, Ordonez M	*Energy Policy*
	53 Wei J, 2017	Driving forces analysis of energy-related carbon dioxide (CO_2) emissions in Beijing: An input-output structural decomposition analysis	Wei J, Huang K, Yang SS, Li Y, Hu TT, et al.	*Journal of Cleaner Production*

52 Su B, 2017	Input-output and structural decomposition analysis of Singapore's carbon emissions	Su B, Ang BW, Li YZ	*Energy Policy*
51 Su B, 2016	China's carbon emissions embodied in (normal and processing) exports and their driving forces, 2006-2012	Su B, Thomson E	*Energy Economics*
45 Wang H, 2017	Multiplicative structural decomposition analysis of energy and emission intensities: Some methodological issues	Wang H, Ang BW, Su B	*Energy*
41 Wang H, 2017	A multi-region structural decomposition analysis of global CO_2 emission intensity	Wang H, Ang BW, Su B	*Energy Economics*
33 Zhao YH, 2016	Driving factors of carbon emissions embodied in China–US trade: A structural decomposition analysis	Zhao YH, Wang S, Zhang ZH, Liu Y, Ahmad A	*Journal of Cleaner Production*
31 Xu SC, 2017	Determination of the factors that influence increments in CO_2 emissions in Jiangsu, China using the SDA method	Xu SC, Zhang L, Liu YT, Zhang WW, He ZX, et al.	*Journal of Cleaner Production*
29 Dong F, 2018	Drivers of carbon emission intensity change in China	Dong F, Yu BL, Hadachin T, Dai YJ, Wang Y, et al.	*Resources, Conservation and Recycling*
29 Mi ZF, 2018	China's "Exported Carbon" Peak: Patterns, drivers, and implications	Mi ZF, Meng J, Green F, Coffman DM, Guan DB	*Geophysical Research Letters*
29 Hoekstra R, 2016	The emission cost of international sourcing: Using structural decomposition analysis to calculate the contribution of international sourcing to CO_2-emission growth	Hoekstra R, Michel B, Suh S	*Economic Systems Research*
29 Zhu BZ, 2018	Input-output and structural decomposition analysis of India's carbon emissions and intensity, 2007/08-2013/14	Zhu BZ, Su B, Li YZ	*Applied Energy*
28 Wu R, 2016	Changes of CO_2 emissions embodied in China–Japan trade: Drivers and implications	Wu R, Geng Y, Dong HJ, Fujita T, Tian X	*Journal of Cleaner Production*
27 Chang N, 2016	Changes in China's production-source CO_2 emissions: Insights from structural decomposition analysis and linkage analysis	Chang N, Lahr ML	*Economic Systems Research*

PDA	44 Wang QW, 2018	Contributions to sector-level carbon intensity change: An integrated decomposition analysis	Wang QW, Hang Y, Su B, Zhou P	*Energy Economics*
	30 Wang H, 2018	Decomposing aggregate CO_2 emission changes with heterogeneity: An extended production-theoretical approach	Wang H, Ang BW, Zhou P	*The Energy Journal*
	28 Du KR, 2017	A comparison of carbon dioxide (CO_2) emission trends among provinces in China	Du KR, Xie CP, Ouyang XL	*Renewable and Sustainable Energy Reviews*