Proceedings of the 6th International Conference on Energy Harvesting, Storage, and Transfer (EHST'22)
Niagara Falls, Canada - June 08-10, 2022
Paper No. 135
DOI: 10.11159/ehst22.135

Study of Eco-Efficiency Based On Quantitative Ecological Trade-Offs

Usman Akbar[1], Rocky J. Dwyer[2]
[1]Yanshan University – School of Economics and Management,
Haigang district, Qinhuangdao, China
usman.akbar@stumail.ysu.du.cn
[2]Walden University – College of Management and Human Potential,
MN USA
rocky.dwyer@mail.waldenu.edu

Extended Abstract

Continued societal demands for products and services have substantially impacted the ability of humankind to fully control an ever increasing global ecological footprint. While short term gains related to reducing waste have resulted in a reduction of the global carbon footprint, continued consumerism needs have pushed industry to producing more carbon than our ecosystems can absorb resulting in a continued rise in global temperatures, changes in weather patterns, increased wildfires, declining water supplies, reduced agricultural yields, health impacts in cities due to heat, flooding and erosion in coastal areas. While demand in consumerism grows, this leads to a snowball effect for land space around the corner and around the world. The impact on the global ecosystem is evident – which has pushed researchers and policymakers keen to identify pathways to not only reduce the ecological footprint, but also to design policies to limit demand under a country's total biological capacity. This phenomenon is also called carbon pricing or CAP.

Previous researchers have calculated efficiencies and proposed solutions to this global challenge in a variety of ways, but quantitative research to support decision-making and policy design continues to lag in relation to need. On the other hand, only pet definitions of trade-offs are considered in the literature – for example, gaining something at the expense of the other. Deng and John [1] analysed existing trade-offs between agricultural production and urbanization and propose agricultural technology changes that may improve the efficiency of sustainable agricultural sector development. On the other hand, a recent new study by Bazyli and Martha [2] investigated the impact of the policy on sustainable European agriculture and explores the trade-offs of environmental, economic and social efficiency. They found that the CAP on the carbon emission has long term impact in terms of efficiency, although the borders implementation on carbon schemes may negatively affect social sustainability because of lower productivity. Laso et al. [3] viewed the canned fish industry which supports a circular economy concept, or what might be considered as a cradle to cradle concept as a means for decision makers to identify environmental and economic trade-off for optimal outcomes, which was also identified Meensel and Lauwers [4], Caiado et al. [5], and Zhao et al. [6].

This current study offers three unique solutions to solve current global challenge of ecological footprints. First, the trade-off concept should not be employed as a compromised function, but rather as an optimal efficiency function. Secondly, the trade-off of ecological assets and ecological footprints should be considered, as both an ecological asset(s) and footprints are interrelated to a country's bio-capacity. Finally, this study recommends the use of indirect pricing (or CAP) methods as opposed to direct pricing, which would limit demand to fair levels. The analysis used in the study is based on both the population and ecological assets (including cropland, grazing land, forest land, fishing grounds, and built-up land) as an input variables. The GDP and bio-capacity (as a productivity of the ecological assets) are treated as the desired outputs, whereas, the ecological-footprint is considered undesired output variable. First the slack based measurement is adopted to find the current efficiency points and then the marginal trade-off concept using the data envelopment analysis (DEA), from the prior study by Ji et al. [7], is considered. Various trade-off rate experiments are conducted in 54 developed countries to determine the optimal efficiency rate to reduce the country's ecological deficit. The optimal interval of +0.5, −0.5 is finally determined as an interval where the ecological assets (i.e. bio-capacity) do not get majorly hurt. Moreover, +0.5 increase on the bio-capacity reduces the ecological footprint up to such an extent that the countries, which were deemed at the efficiency frontier line, gain the optimal efficiency point. The interesting fact of these findings is that the efficiency and productivity of ecological assets are maintained at a level that meet the needs of the

general public, while enabling policymakers to design policy that help maintain acceptable levels of productivity and curb excessive consumption of a country's total bio-capacity.

References

[1] X. Deng and J. Gibson, "Improving eco-efficiency for the sustainable agricultural production: A case study in Shandong, China," *Technol. Forecast. Soc. Change*, vol. 144, pp. 394–400, 2019.

[2] B. Czyżewski and M. Guth, "Impact of Policy and Factor Intensity on Sustainable Value of European Agriculture: Exploring Trade-Offs of Environmental, Economic and Social Efficiency at the Regional Level," *Agriculture*, vol. 11, no. 1, p. 78, 2021.

[3] J. Laso, I. García-Herrero, M. Margallo, I. Vázquez-Rowe, P. Fullana, A. Bala, C. Gazulla, Á. Irabien, and R. Aldaco, "Finding an economic and environmental balance in value chains based on circular economy thinking: An eco-efficiency methodology applied to the fish canning industry," *Resour. Conserv. Recycl.*, vol. 133, pp. 428–437, 2018.

[4] J. Van Meensel and L. Lauwers, "Eco-efficiency indicators: do they suffice for analyzing economic-environmental trade-offs?," *2nd World Sustain. Forum*, 2012.

[5] R. G. G. Caiado, R. de Freitas Dias, L. V. Mattos, O. L. G. Quelhas, and W. Leal Filho, "Towards sustainable development through the perspective of eco-efficiency-A systematic literature review," *J. Clean. Prod.*, vol. 165, pp. 890–904, 2017.

[6] W. Zhao, G. Huppes, and E. Van der Voet, "Eco-efficiency for greenhouse gas emissions mitigation of municipal solid waste management: A case study of Tianjin, China," *Waste Manag.*, vol. 31, no. 6, pp. 1407–1415, 2011.

[7] T. G. Ji, A. Raza, U. Akbar, M. Ahmed, J. Popp, and J. Oláh, "Marginal Trade-Offs for Improved Agro-Ecological Efficiency Using Data Envelopment Analysis," *Agronomy*, vol. 11, no. 2, p. 365, Feb. 2021.