System reproducibility within planetary boundaries and basic needs satisfaction

Topic: Input-Output Analysis: Sustainable Production and Consumption policies (11)
Author: Facund Fora-Alcalde
Co-Authors: angelo piga, Costantino Budroni, Lorenzo Di Domenico

The global economic system consumes natural resources at a rate that exceeds the planet's regenerative capacity, yet it still fails to guarantee the majority of the population access to the material goods necessary for their well-being (Oâ€™Neill 2018, Tian 2024). Faced with this dual problem, several authors have explored the possibilities of satisfying the basic needs (Rao 2019) of the world's population within the Earth's biophysical limits (Steffen 2015). To the best of our knowledge, this research has always followed a demand-driven approach: it has defined bundles of goods needed for peopleâ€™s wellbeing and has computed the requirements, in terms of labour, emissions and several natural resources, for producing those bundles (McElroy 2025). In this endeavour, most authors have used input-output models and, particularly, Leontiefâ€™s inverse matrix to translate specific, exogenously defined vectors of final demand into total requirements of goods and resources.
We investigate the problem of optimal consumption while simultaneously respecting the following constraints: 1) the satisfaction of basic needs is guaranteed for the entire population; 2) planetary boundaries are not exceeded; and 3) the economic system can sustain itself (condition of simple reproduction). We formulate this problem, within a closed Leontief input-output model that describes the current production technologies, as a linear optimization problem, which can be solved efficiently for complex models, e.g., with hundreds of thousands of parameters. Basic needs and planetary boundaries are defined according to the social, climate and environmental science literature (Oâ€™Neill 2018); while the simple reproduction condition holds when the dominant eigenvalue of the labour-augmented matrix (where labour is treated like any other means of production) is equal to one.
Such an approach is inspÃ¬red by the seminal works of Piero Sraffa (1960) and Andras Brody (1970). Even if these were published in the 60s and 70s of the last century, there have been limited empirical applications integrating a purely sector-based economic feasibility with environmental limits. The recent publication of environmentally extended global multi-regional IOTs, such as EXIOBASE (Stadler 2018) and GLORIA (Lenzen 2017), as well as the increasing literature concerning the planetary boundaries, nowadays allows to perform such an exercise.
Different assumptions regarding the technology in use are possible, and we explore three of them: the case in which the worldâ€™s technology corresponds exactly to the one currently in use derived from actual global multi-regional input-output tables; another scenario in which all countries of the world operate with an â€˜advancedâ€™ technology, which is assumed to be the one currently in use in the United States of America; and the third case in which the worldâ€™s technology corresponds to a low-middle-income nation, which is assumed to be the one currently in use in India. For each case we examine different scenarios of distribution between wages and profits.
The results allow us to assess the possibilities for material wellbeing at a global scale in different technology scenarios and for different sizes and compositions of the global population. In this way, the methodology used here, as well as the empirical outcomes, can be of use in policy making and, thus, contribute to the sustainability of the global economy and to its success in providing wellbeing to its inhabitants.

BIBLIOGRAPHY
BrÃ³dy, AndrÃ¡s. Proportions prices and planning. A mathematical restatement of the labor theory of value. AkadÃ©miai KiadÃ³, 1970.
Lenzen, Manfred, et al. "The Global MRIO Labâ€“charting the world economy." Economic Systems

Research 29.2 (2017): 158-186.
McElroy, Chris, and Daniel W. Oâ€™Neill. "The labour and resource use requirements of a good life for all." Global Environmental Change 92 (2025): 103008.
Oâ€™Neill, Daniel W., et al. "A good life for all within planetary boundaries." Nature sustainability 1.2 (2018): 88-95.
Rao, N.D., Min, J., Mastrucci, A., 2019. Energy requirements for decent living in India, Brazil and South Africa. Nat. Energy 4, 1025â€“1032.
Sraffa, Piero. Production of commodities by means of commodities. Vol. 64. Cambridge University Press: Cambridge, 1960.
Stadler, Konstantin, et al. "EXIOBASE 3: Developing a time series of detailed environmentally extended multiâ€•regional inputâ€•output tables." Journal of Industrial Ecology 22.3 (2018): 502-515.
Steffen, Will, et al. "Planetary boundaries: Guiding human development on a changing planet." science 347.6223 (2015): 1259855.
Tian, Peipei, et al. "Keeping the global consumption within the planetary boundaries." Nature 635.8039 (2024): 625-630