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# THE MEASURE OF GROSS DOMESTIC PRODUCT (GDP) IN THE SYSTEM OF ACCOUNTS FOR GLOBAL ENTROPY PRODUCTION

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## ABSTRACT

Gross Domestic Product (GDP) are values conserved-in-exchange (or prices) of all the final goods and services produced per annum by the Nation. The I/O matrix of market-value GDP assumes a symmetric translation (or mapping) → I/O matrix of the Material-Energy Balance Statistical System,
(MEBSS).[1] The paper applies the Second Law of Thermodynamics to GDP.

SAGE-P assumes a three-dimensional accounting structure of economic, social and ecological values mapped on any well-defined I/O algorithm of (material) production → neg-entropy and consumption → entropy. The 'balance sheet' assumes the measure of the quantities and qualities (health, integrity and resilience) of economic, social, human and natural capital. The latter are redefined in terms of the Low Entropy Fund (LEF) available for human consumption, ( Georgescu-Roegen,1971).

This paper describes the statistical method, with a special focus of algorithms for mining 'Big Data' and the conceptual potential for restructuring the System of National Accounts, (SNA) to be consistent with the Second Law of thermodynamics.

Government Policies of Climate Change, among other emergent issues of the Digital Age, are framed in the measure of economic growth in GDP. De-growth of GDP is seen by many experts, as a necessary condition for transition to net-zero greenhouse gas emission and towards a green economy. At the same time, higher incomes (work) are seen as a trade-off for leisure and self-actualization.

The trade-off in Policies measured against de-growth in GDP is illusionary. The proper focus of transitions Policies toward the so-called Green Economy, is found in entropy efficiencies measures of (a) consumption, (b) production and (a) capital. This may be formulated as a policy objective:

(a) Decrease to a minimum any socially acceptable rate of *entropy production* per unit of consumption, (i.e., values conserved in use and/or participation);

(b) increase to a maximum any economically acceptable rate of *neg-entropy* production per unit of production, (i.e., values conserved in exchange and/or prices);

(c) maintain the Low Entropy Fund available for human consumption at sustainable rate of entropy production. ion

GDP is expressed as a (linear) measure of the annual production of the (final) goods and services produced in the Domestic Economy measured at market prices. It is a gross value insofar as it does not subtract from GDP the annual rate of depreciation of the Nation's stock of Economic, Social, Human and Natural Capital upon which GDP is a fully dependent variable. The accounts are constructed from the following identities: (a) Production, P ≡ Y (Income), (i.e., payments for work and/or dividend/rent), (b) Consumption, C ≡ E, (Expenditure), (i.e., payments for goods and services), (c) Capital, K ≡ S (Saving), and (d) Trade with the rest-of-the World, T ≡ X (Exports) - M (Imports) ≡ deficit/surplus in the balance-of-trade.

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1 Materials and energy balances are accounting tables that provide information on the material input into an economy delivered by the natural environment, the transformation and use of that input in economic processes (extraction, conversion, manufacturing, consumption) and its return to the natural environment as residuals (wastes). The accounting concepts involved are founded on the First Law of Thermodynamics, which states that matter (mass/ energy) is neither created nor destroyed by any physical process. (Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997).

The SAGE-P enables any well-defined objects and/or functions of the GDP to be translated in the language of 'thermodynamics' expressed as equivalences (i.e., symmetries) of entropy production. Thus, production (P), consumption (C) and capital accumulation (K) are reformulated into the statistics of: (a) neg-entropy production, (Pe), (b) entropy production, (Ce) and (c) net-value of entropy production, (Pe - Ce = Ke), where Ke ≡ Low Entropy Fund [LEF] available for human consumption at any instant in time (t). Trade with the rest-of-the-world assumes the flow across the boundary of the the nested topological domain spaces (TDS): (A) Ecosphere, [(B) Sociosphere, {(C) Econosphere]} where export Xe = outflow and import Me = inflow of entropy production.

The outflow of entropy production (e.g., waste residuals) of the (material) GDP are mapped to the TDS of A → as values conserved-in-themselves, (i.e., existential), the TDS of B → as values conserved-in-use, (i.e., participation) and TDS of C → as values conserved-in-exchange, (i.e.,prices). The value mapping is reversed for the inflow of LEF into the GDP. LEF may be assessed in both time and space in the following state-conditions: (i) Surplus-state

= Pe/Ce > 1, (ii) Deficit-state = Pe/Ce < 1, and (iii) Steady-state = Pe/Ce = 1.

The assessment of sustainable GDP are the anticipatory models of the future state conditions of the LEF of the Nation available for human consumption. This may be further reduced to projections of surplus, deficit or steady- state condition of: (a) primary production (i.e., harvesting/extraction), (b) secondary production, (i.e., manufacturing) and (c) tertiary production, (i.e., services). The policy objective is to reduce to an absolute minimum the rate of entropy production per unit of consumption given: (a) the current, and future, state of technology, (b) the minimum socially acceptable rate of entropy and (c) limits of the Ecosphere to the material-energy engendered by GDP.