Beyond GDP: The Wealth Perspective of Sustainability

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Abstract

The capital approach, or the wealth economy framework of sustainability broadens the conventional measure of economic performance "beyond GDP", with a long-term view. The totality of capital assets, or wealth, is composed of produced, human, natural and social capital, and is seen as the source of income, benefits, and wellbeing of present and future generations. Shrinkage in this production base signals unsustainable development. While the weak criterion of sustainability allows substitution between all capital elements, the strong criterion does not allow reductions in the renewable component of natural capital. Using World Bank data, we found that during the 1995-2018 period, 14% and 58% of the countries globally did not meet the weak and the strong criteria of sustainability, respectively. Also, a comparative analysis of wealth and its components is provided for selected OECD countries. It is found that human capital is proportionally the most significant among the capital elements, followed by produced capital. Natural capital, both renewable and non-renewable, lags far behind. Our findings raise questions regarding the rationale of economic convergence, as well as confirm the necessity of further methodological improvements regarding data generation and statistics, including the valuation of assets.

Keywords: Sustainability; wealth economy, wellbeing

JEL codes: Q01, Q51, Q56

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Introduction

The definition of sustainability in the Brundtland report[1] can be seen as the conceptual foundation of measuring the sustainability of development "beyond GDP", as it provides an appropriate starting point to contemplate the complexity of interlinkages between the biosphere and the socio-economic systems. In political philosophy, sustainability is conceptualized as *justice between generations* (Meyer, 2021; Tremmel, 2009); in economics, as *intergenerational wellbeing* that moves in unison with wealth, the totality of capital assets available for the socio-economic system. Therefore, changes in wealth is an indicator of sustainability (Arrow et al., 2010).

To judge the performance of an economy from the perspective of sustainability, Dasgupta (2009) classifies four categories of indices, depending on the question they answer: "(A) How is the economy doing now? (B) How has its performance been in recent years? (C) How is it likely to perform under alternative policies? and (D) What policies should be pursued there?". (A)-(C) are descriptive approaches, (D) is a normative question. GDP is the indicator to answer questions (A) and (B), however, it cannot be used to assess the future, or alternative development paths for the economy regarding questions (C) and (D). Dasgupta references a long list of theoreticians and concludes that concerning enquiries regarding sustainable development such as questions (C) and (D), the right index is a comprehensive measure of wealth, which is at the disposal of the socio-economic system, in the broadest sense.

Hamilton and Hepburn (2014) discuss GDP and its use from a historical perspective and explain why wealth[2], a complementary to GDP, is the right indicator of sustainability, considering its intertemporal and intergenerational aspects. Arrow et al. (2010) show that wealth and wellbeing move in unison, therefore, intergenerational wellbeing would not decline if (resulted from the economic activity) comprehensive wealth does not decline. In this article this definition of sustainability is used.

Wealth, the source of income and benefits today and in the future, is composed of the capital assets available for the society: reproducible capital assets (buildings, infrastructure, machines), human capital (characterized by

[1] "...development is sustainable...if the needs of the present are met without compromising the ability of future generations to meet their own." (Brundtland, 1987 para. 27.)

[2] The notion comprehensive wealth is commonly used in the literature meaning the totality of capital assets.

features of the population, demography, health, education, skills etc.), natural capital (ecosystems, minerals, fossil fuels etc.) and social capital (norms, traditions, beliefs, societal coherence, identity, institutions etc.) (Dasgupta, 2021a, p. 181). The change of wealth over time is a sustainability indicator that should be used to measure economic progress or its absence (ibid. p. 321). Works by Dasgupta are built on the theoretical foundations laid earlier by Pearce and Atkinson (1993), among others, who distinguished weak and strong sustainability. The criteria of *weak sustainability* require that the overall capital base should not decline, while *strong sustainability* does not allow the depreciation of any 'critical' natural capital element. From the sustainability perspective, reductions in the non-renewable elements of natural capital (minerals, oil and gas reserves) can be compensated by the increase of other types of capital, for instance produced, or human capital. In this context, according to Hartwick's rule (Hamilton, 1995; Hartwick, 1977)the consistency of this concept with the Hartwick rule and optimal growth is explored when resources are exhaustible. A simple proof that a generalized Hartwick rule is necessary and sufficient for constant consumption is derived. The existence of a maximal constant consumption path is shown to depend critically on the elasticity of substitution; if this is less than 1, consumption declines; if it is greater than 1 then consumption is not maximal; if it is equal to 1 (the Cobb-Douglas case, in order to maintain sustainability, rents from natural resources should be re-invested in human or natural capital, i.e. education, health and protection of the environment.

According to the classification used in the ecosystem accounting framework (SEEA EA[3]), non-renewable natural capital reserves can be seen as the assets that provide the provisioning services of an ecosystem. The renewable component of natural capital can also provide provisioning services (e.g. wood, fish, plants), and is the source of regulating and recreational services as well. Biodiversity[4] is of basic importance for the functioning of ecosystems. The Common International Classification of Ecosystem Services (CICES) provides a broadly accepted, unified framework that underlines the development of the global system of natural capital accounting. In Europe, the related standards are set by the INCA project (La Notte et al., 2022), while in the United States, the implementation of environmental-economic accounting is guided by a strategy document (White House, 2023).

[3] System of Environmental Economic Accounting Ecosystem Accounting, a global statistical standard developed by the United Nations.

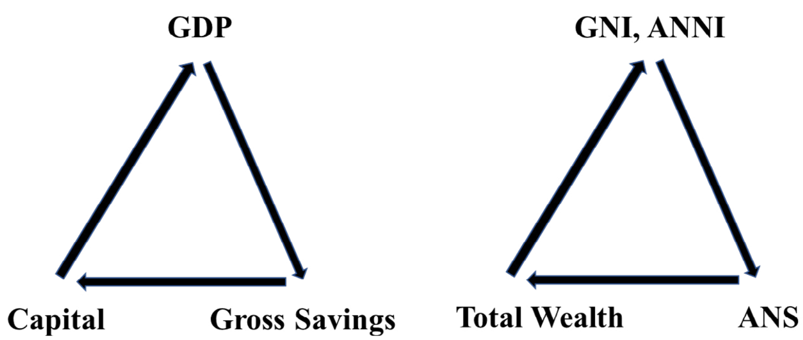
[4] "Biodiversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which are part: this includes diversity within species, between species, between species and of ecosystems." (United Nations, 1992)

In the wealth economy framework, empirical analysis of sustainability, weak or strong, is problematic, primarily for two reasons: it is not unequivocal how exactly (1) the totality of capital assets should be compiled and (2) the values of the various capital elements measured. In practice, to sum the values of assets, existing statistical data can be used, which obviously is an approximation, and which would probably exclude several, otherwise important capital elements, in particular ones that concern human or natural capital. Regarding the problem of asset valuation, Inclusive Wealth (IW)[5] is defined as the sum of the *accounting values* of the economy's stocks of various capital elements (Dasgupta, 2021a, p. 324). Nevertheless, even the accounting value of most capital elements is difficult to define. Accounting values are supposed to reflect on societal preferences and asset values that change over time and are also relative to each other. Therefore, accounting prices are not market prices, and the approximations based on market-values can be applied with limitations only, as rough estimates. Markets and market prices usually exist in case of the components of produced capital. However, the values of the components of human and natural capital (which are usually without market prices) can be assessed based on approximations, which raises both conceptual, as well as methodological problems (Dasgupta, 2021a, chap. 12; Marjainé Szerényi and Kovács, 2018).

Empirical research of economic growth usually focuses on the interlinkages between three variables: *output, savings* and *capital* i.e., *GDP, Gross National Savings* and capital assets, shown in Figure 1 (left triangle), which are traditionally accounted for in national statistics.

Figure 1: Macroeconomic cycle, traditional and sustainability focus

Source: Own construct

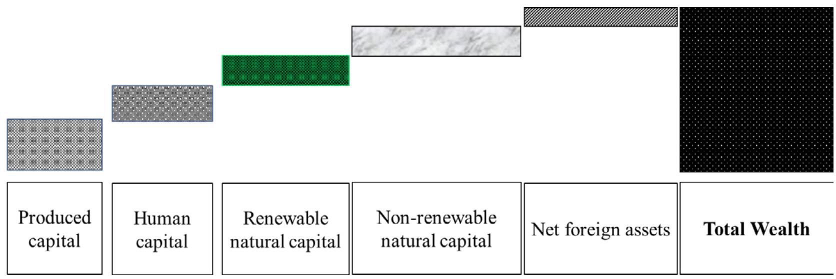


[5] IW is an indicator introduced by Managi (2016).

Regarding sustainability research, amended versions of the three indicators are preferable (Figure 1, right triangle): *Total Wealth* and its components, *produced, human, renewable natural capital, non-renewable natural capital* and *net foreign assets* (Figure 2); *Gross National Income* (GNI)[6] and *Adjusted Net National Income* (ANNI)[7] are income indicators, adjusted net savings (ANS)[8] is a savings indicator. Data of all these indicators can be sourced from the database of the World Bank (Kovács, 2022). The composition of Total Wealth is shown in Figure 2. All components are, by definition, positive, except for Net Foreign Assets, which may increase or decrease Total Wealth, depending on whether the country is a net lender or borrower.

Figure 2: Composition of Total Wealth

Source: Own construct based on (World Bank, n.d.)



Our research focuses on testing the sustainability of nations globally, against the weak and the strong criteria, using World Bank data. The article is organized as follows: Section 2 provides a review on the theoretical foundation and reference literature of the research. The construct, research methodology and the data are presented in Section 3, followed by the analysis and research results in Section 4. Discussion and summary conclude in Section 5 and Section 6, respectively.

[6] GNI: sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income from abroad.

[7] ANNI: GNI minus consumption of fixed capital and natural resources depletion.

[8] ANS: gross national savings minus depreciation plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, and carbon dioxide and particulate emissions damage.

1. Macroeconomic theory and empirics of sustainability

1.1. Theory

By definition, development is sustainable if, over time, wellbeing is not declining (Arrow et al., 2010). *Intergenerational wellbeing* is defined as the present value of the flows of felicities[9], benefitted by future generations, expressed with Eq.[1] (Dasgupta, 2019):

$$[1] \quad V(t) = \int_t^{\infty} \left[U\big(C(s)\big)e^{-\delta(s-t)}\right]ds, \quad \delta \geq 0,$$

where V(t) is intergenerational wellbeing at t, [U(s))..] is the utility at time s, which is a function of the vector of consumptions, with the logarithmic discounting formula e$^{-\delta(s-t)}$. This wellbeing-consumption is denoted intergenerational benefits by Bretschger and Valente (2023) that, unfolding [1] into [2] , is a function of the consumption of produced goods (c), the quality of the environment (q) and an index of demography (n).

$$[2] \quad V(t) \equiv \int_0^{\infty} u(c(t), q(t), n(t))e^{-\rho(n(v)dv)}dt,$$

According to (Arrow et al., 2010) development (of the socio-economic system) is sustainable (at a point of time), if intergenerational wellbeing (at that point of time) does not decline, i.e.:

$$[3] \quad \frac{dV}{dt} \geq 0.$$

In practice, identifying and measuring the future flows of wellbeing utilities (felicity) is problematic, and Arrow et al. (ibid.) propose that intergenerational wellbeing and sustainability could be traced by the changes in (comprehensive) wealth. As these two move in unison, the socio-economic system is sustainable if overall wealth does not decline over time. The weak criterion of sustainability is then defined by Eq.[4]:

$$[4] \quad 0 < \frac{dW}{dt} = \frac{dK}{dt} + \frac{dH}{dt} + \frac{d(R+E)}{dt},$$

[9] The expression *felicity* can be originated from Aristotle' "eudaimonia", which is well addressed by contemporary political philosophy (Hörcher, 2020; Scruton, 2014; Sen, 1990).

where **W** is the practical approximation of the totality of wealth, K is produced capital, H is human capital, and R and E are the non-renewable and renewable components of natural capital, respectively. Kerekes et al. (2007; 2018), quoting Pearce and Attkinson, provides the following, transformed definition:

$$0 < Z = \frac{S}{Y} - \frac{\delta_M * K_M}{Y} - \frac{\delta_N * K_N}{Y}$$

where S is savings, Y is GDP, and and are the rates of amortization of produced (man-made) capital *(K_M)* and natural capital *(K_N)*. Accordingly, the strong criteria of sustainability can be expressed, as follows:

$$\frac{\delta_N * K_N}{Y} > 0$$

According to Pearce and Atkinson (1993) strong sustainability does not allow reductions in natural capital. Dasgupta (Dasgupta, 2021a) narrows further the strong criterion focusing on changes in the renewable component of natural capital ($(\frac{dE(t)}{dt})$), according to Eq. [5]:

$$[5] \quad 0 < \frac{dE(t)}{dt}.$$

Hereinafter, the sustainability of nations is tested against the weak and strong criteria according to Eq.[4] and Eq.[5], respectively.

1.2. Empirical research of global wealth

The literature on wealth economy has grown rapidly over the past few years. For example, in 2023, the keywords of “wealth and sustainability” resulted in more than 15 thousand hits by Google Science. The World Bank’s series on the wealth of nations is a major source of theoretical and empirical studies of the field (World Bank, 2021). The most recent report of the series provides a thorough analysis of the wealth of nations globally, based on two foundations: (i) the theoretical approach to sustainability, which is conceptualized by the Dasgupta Model (Dasgupta, 2021b, 2021a) and (ii) the renewed Wealth Accounts database of the World Bank (World Bank, n.d.). The Wealth Accounts database is currently the only open-access repository of global wealth data, which, structured in accordance with the theoretical foundations of the wealth perspective of sustainability, can be directly used for a theory based global empirical analysis of sustainability.

In the first part of the recent World Bank report, after a "how to read" chapter, Lange and Naikal discuss issues related to measuring wealth, as well as the recent methodological improvements of the Wealth Accounts database (2021). Then, a detailed global analysis of the changes in wealth and its components is provided by Lange et al. (Lange et al., 2021b), which focuses mainly on geographic regions and specifics of countries in various income groups. A main finding of the report is that the growth in the renewable natural capital component of wealth globally lagges behind that of other wealth components, and markedly behind GDP as well. This is likely to pose growing risks concerning the ecological foundations of future economic performance of the overall socio-economic system.

The chapters in the second part of the report are devoted to specific issues, such as the natural capital assets of mangroves and fisheries, which has recently been incorporated in the database; the impact of the COVID 19 pandemic (Karakulah et al., 2021b) and air pollution on human capital (Karakulah et al., 2021a). The third part of the document addresses the application of wealth accounting in policy analysis (World Bank, 2021, chaps. 9–15). While the document provides an in-depth view on global wealth, the wealth perspective of sustainability, as such, is not addressed.

According to the Dasgupta Review (Dasgupta, 2021a), a main reference of the World Bank report, managing sustainability is an issue of portfolio management across generations, i.e., the maintenance of the asset base, which is the source of income and benefits, to be enjoyed by future generations. Therefore, it is of utmost importance to contemplate the complexities of the interrelations between economic performance (income generation), macro-fiscal policies (sharing income between consumption and savings) and wealth-generation. To address a specific aspect of this complex problem, Cust and Ballesteros (Cust and Ballesteros, 2021) investigate the interlinkages between wealth and income generation, using the World Bank's Wealth Accounts and the World Development Indicators database.

Yamaguchi et al. (2023) provide a global perspective of the literature on natural capital and wealth accounting, in the context of assessing sustainability. The study is a very rich, up-to-date synthesis of the elements of the wealth accounting framework, which is becoming a real alternative to the GDP based assessment of economic progress. The nexus of the Dasgupta Review, the Wealth Accounts database of the World Bank and the UN developed SEEA EA are considered the foundations of an economic thinking with a long-term view on economic performance bounded in a limited biosphere and challenged by impact inequality[10], climate change, population issues etc. The literature on "gray"[11], "green"[12] and "blue"[13] natural capital is reviewed, then the article concludes that wealth accounting needs to be updated to reflect spatial aggregation issues, upscaling from micro to macro, risks and uncertainties, as well as the problems regarding the pricing (valuation) of capital elements, most importantly natural capital. The need for new indicators "beyond GDP" is emphasized, as well.

2. Research plan, methodology and data

Our goal is to contribute to the literature on global wealth and sustainability by investigating if the countries in the World Bank database performed sustainably during the 1995-2018 period or not. We aim to analyze weak and strong sustainability of the countries according to Eq. [4] and Eq.[5]). To the assessment, the geometric growth rate of Total Wealth (TWg), as well as that of the renewable component of natural capital (Eg) over the period is used as indicator, which, as an annual average, ignores temporal effects, and allows the comparative assessment of different economies. Positive rate of growth means sustainable economic performance over the period, negative growth rate means unsustainability.

For the analysis, the recently renewed version of the Wealth Accounts database in World Bank Open Data (WBOD) is used, which includes yearly time series data of Total Wealth and its components for 146 countries from 1995 to 2018.

In the Wealth Accounts database, Total Wealth is defined as the sum of produced, natural and human capital, as well as net foreign assets (World Bank, n.d.). Values of Total Wealth are calculated at market exchange rates in constant US$ 2018, using a country-specific GDP deflator. Data for the different capital components are sourced from national statistics. Values for produced capital and net foreign assets are generally derived based on observed transactions. In the absence of international standards, the values of natural capital and human capital components are based on estimates.

[10] The notion of impact inequality, introduced by Dasgupta (2021a), is the ratio between the ecological footprint and the regeneration capacity of the global biosphere, recently assessed 1,7.

[11] "Grey" natural capital is composed of fossil fuel, mineral and metal resources.

[12] "Green" natural capital means renewable natural capital.

[13] "Blue" natural capital stands for non-terrestrial, marine resources.

The approach to asset valuation is based on the concept that the value of an asset should equal the discounted stream of expected net earnings (resource rents or wages) that it earns over its lifetime. The discount rate used for the valuation is 4%. To account for changes in population, per capita data is used for the analysis. Data statistics of Total Wealth and its components, as well as growth rates are shown in Table 1. and Table 2, respectively. The conceptual variable of *E* in Eq.[4] and Eq. [5] is marked by NCpCR.

Table 1: Descriptive statistics, Total Wealth and its components, global, 2018, USD/cap

Source: Author's analysis based on World Bank Open Data (World Bank, n.d.)

Variable	Observa-tion	Mean	Min.	Max.
TWpC	145	183 919	4 594	1 280 371
PCpC	145	62 842	515	412 587
HCpC	145	100 328	668	796 353
NCpCN	145	10 245	-	343 147
NCpCR	145	6 519	62	32 883

where:

- TWpC – Total Wealth per capita;
- PCpC – Produced capital per capita;
- HCpC – Human capital per capita;
- NCpCN – Non-renewable natural capital per capita;
- NCpCR – Renewable natural capital per capita;

Table 2: Descriptive statistics, growth rates of capital elements, global, 1995-2018, %

Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)

Variable	Observa-tion	Mean	Min.	Max.
TWpCg	145	1,60	-2,98	7,43
PCpCg	145	2,37	-4,77	9,96
HCpCg	145	1,96	-2,63	8,84
NCpCNg	118	4,42	-9,63	68,06
NCpCRg	145	-0,55	-12,09	3,01

3. Analysis and results

3.1. Global sustainability

Table 3 shows the number of countries in which the performance of the economy during the 1995-2018 period did not meet the weak criterion of sustainability.

Table 3: Number of unsustainable countries, weak criteria, World Bank country income groups, 1995-2018

Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)

	Low income	Lower-middle income	Upper-middle income	High income	Total
TWpCg<0	7	3	6	4	20
Wealth Accounts database*	20	38	40	44	142
World Bank full database	27	55	55	80	217

The relative number of non-sustainable countries in the different income groups differ: the rate is the highest among Low-income countries (7/20), followed by Upper-middle income countries (6/40). In the Low-middle income and High income group the number of unsustainable countries is relatively low, (3/38 and 4/44, respectively). Overall, the number of non-sustainable counries is 20/142, about 14%.

Table 4 shows the number of countries that did not meet the strong criterion of sustability over the 1995-2018 period.

Table 4: Number of unsustainable countries, strong criteria, World Bank country income groups, 1995-2018

Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)

	Low income	Lower-middle income	Upper-middle income	High income	Total
NCpCRg<0	14	23	25	21	83
Wealth Accounts database*	20	38	40	44	142
World Bank full database	27	55	55	80	217

The relative number of non-sustainable countries is the highest in the Low-income group (14/20) and the lowest in the High-income group (21/44). Altogether 83/142 countries do not meet the strong criteria of sustainability, which is 58% of the countries in the database.

3.2. Wealth in the OECD countries

Table 5 shows the statistics of per capita wealth data of 35 OECD countries in 2018. Concerning Total Wealth and the various elements of wealth, significant differences can be seen between minimum and minimum values. Also, there are significant differences between the proportions of the different capital elements within Total Wealth.

Table 5: Descriptive statistics, Total Wealth and components, 2018, OECD, USD/cap

Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)

Variable	Obs.	Mean	Min.	Max.
TWpC	35	498 238	43 071	1 280 371
PCpC	35	185 907	23 119	412 587
HCpC	35	293 215	11 212	796 353
NCpCR	35	10 965	2 755	32 883
NCpCN	35	4 230	0	54 370

Considering the mean values, the proportion of human capital is the highest, followed by produced capital; renewable natural capital lags far behind and finally, the value of non-renewable natural capital is proportionally the lowest. Table 6 shows the wealth statistics of selected OECD countries in 2018. (Net foreign assets, which are not in the focus of the analysis, are not shown in the table, therefore, produced capital, human capital, renewable and non-renewable capital do not sum-up to Total Wealth.). The share of the various capital elements in these countries follow the overall trends of the OECD countries (Table 5).

Table 6: Descriptive statistics, Total Wealth and components, 2018, selected OECD countries, USD/cap

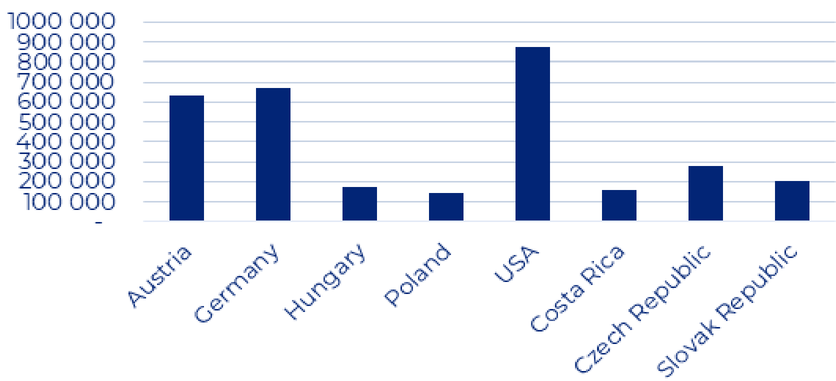
Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)

	TWpC	PCpC	HCpC	NCpCR	NCpCN
Austria	633 748	269 968	351 301	11 578	362
Germany	672 408	258 165	381 761	5 292	232
Hungary	174 761	77 142	100 149	5 535	150
Poland	139 207	40 898	99 685	5 300	1 725
USA	872 400	263 930	621 460	12 977	4 303
Costa Rica	158 035	30 255	120 291	13 918	2
Czech Republic	275 897	130 118	144 851	5 456	744
Slovak Republic	200 594	77 615	130 599	5 272	184

Figure 3 shows per capita Total Wealth figures (TWpC coloumn in Table 6) of the selected OECD countries, indicating far higher per capita wealth in Austria, Germany and the USA than the V4 countries (Hungary, Poland, Czech Republic and Slovak Republic) and Costa Rica. Intuitively, it can be said that this large gap concerning the wealth of nations could provide an additional perspective for assessing the convergence of less developed economies to the group of high-income caountries.

Figure 3: Total Wealth, selected OECD countries, 2018, USD/cap

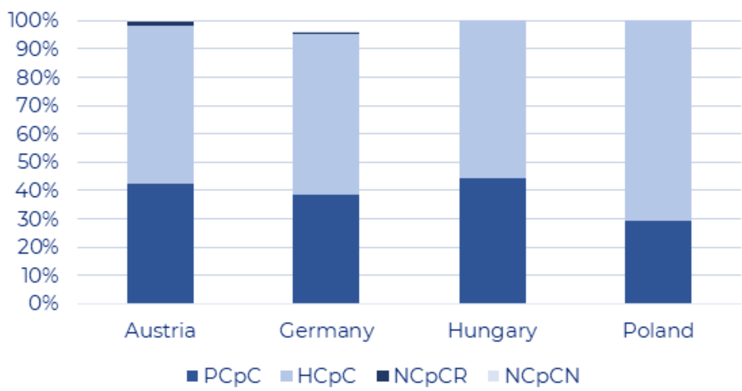
Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)



The proportions of the elements of Total Wealth in four selected OECD countries are shown in Figure 4. It is outstanding that, in case of every country shown in the figure, the share of human capital is the highest, followed by that of produced capital, while the shares of natural capital (both renewable and non-renewable) are insignificant.

Figure 4: Structure of wealth, selected OECD countries, 2018

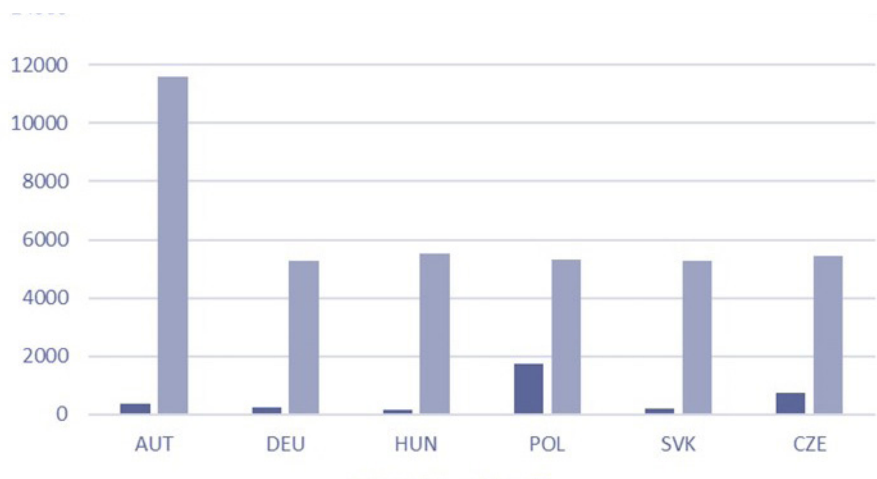
Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)



Also, as an example, the per capita figures of the renewable and non-renewable components of natural capital in the selected OECD countries are shown in absolute terms in Figure 5. In these countries, the value of non-renewable natural capital assets, i.e. fuel, mineral and metal resources are small, except for Poland, which owns significant coal reserves.

Figure 5: Natural capital, selected OECD countries, 2018, USD/cap

Source: Authors' analysis based on World Bank Open Data (World Bank, n.d.)



Renewable natural capital in these countries amount to approx. 5.000-5.500 USD per capita, except for Austria, which is relatively rich in renewable natural resources, exceeding 11.000 USD per capita.

4. Discussion and further considerations

The results of the analysis show that 14% of the countries in the Wealth Accounts database of the World Bank did not meet the weak criteria of sustainability over the 1995-2018 period. As an even more unnerving result, 58% of the countries did not meet the strong criteria of sustainability over the same period. Globally, these results can be considered conservative, as they account for only 146 of the 217 countries in the global database of the World bank. There is a good reason to assume that those countries not included in the Wealth Accounts database are relatively under-developed and their economic performance is probably unsustainable. Also, they might not have the statistical infrastructure necessary to provide the figures which would be sufficiently accurate to assessing wealth. (Israel and New Zealand can be seen as exceptions, which are OECD members, yet are not included in the Wealth Accounts database of the World Bank.) Therefore, while our results may not be globally representative, the actual share of non-sustainable countries in the world may exceed the figures found in our research.

The problem of data harmonization is seen as another limitation of our results. Although national statistics are structured based on an international standard (UN System of National Accounts), there may be differences in how this standard is implemented, depending on the organization and capacity of statistical institutions. Therefore, the database of the World Bank may not be fully harmonized.

Pursuant to theory, wealth is the sum of the social value of the totality of assets. It is obvious that in practice, Total Wealth does not include all the capital assets of the socio-economic system. Therefore, Total Wealth is an indicative estimate of the totality of the value of the capital assets. Also, asset values are based on market prices, in case the market exists, or alternatively, calculated by other, for instance preference-based methods. However, values based on both of these methodologies can be considered only as estimates of the theoretical values, and it is highly uncertain to what extent these practical values can approximate the theoretical, social values of the assets.

Our findings provide additions to the results of previous research on sustainability, both from global and national perspectives. The 2021 World Bank report (World Bank, 2021) focused on investigating trends in the development of the different types of capital assets, and, in this regard, explained the methodological improvements of the recent version of the Wealth Accounts database. Our study attempted to contribute to the contemplation of the perspectives of global sustainability by providing further empirical results according to country income-groups. Our results demonstrate increasing sensitivity and vulnerability of the economies at lower income levels. Nevertheless, such risk exists in high-income economies as well. In Bahrein, Oman and Saudi Arabia, all natural resources-rich exporters, sustainability is at risk, even in the weak sense.

The results of our research may raise serious questions concerning the feasibility of the expected convergence between developed and less-developed economies. Lange et al. (2021a) emphasize the Hartwick concept (Hamilton, 1995; Hartwick and Hamilton, 2014)the consistency of this concept with the Hartwick rule and optimal growth is explored when resources are exhaustible. A simple proof that a generalized Hartwick rule is necessary and sufficient for constant consumption is derived. The existence of a maximal constant consumption path is shown to depend critically on the elasticity of substitution; if this is less than 1, consumption declines; if it is greater than 1 then consumption is not maximal; if it is equal to 1 (the Cobb-Douglas case, saying that, in order to pursue economic convergence, resource-rich developing countries should reinvest income from the exports of non-renewable resources into human and natural capital (Lange et al., 2021a). If the linearity between wealth and economic growth is conceptually approved so that an income level comparable with that of the developed world can be attained, per capita wealth in developing countries should multiply tenfold within a reasonable timeframe, i.e., within decades, which is unrealistic. This implies that the perspectives of converge in terms of income, using the GDP metrics, even for relatively developed economies, is strongly doubtful.

These findings may be disappointing. Nevertheless, the methodological improvements in data generation and analysis may substantially change the perspective on global sustainability, which sets the path for further research.

Summary

Our research aimed to contribute to the contemplation of sustainability using the wealth economy framework. Our analysis is based on the recent advances of macroeconomic theory and use the renewed Wealth Accounts database of the World Bank. Unsustainability has been found in the case of a high number of countries globally in every income group, including high-income economies. The results may question the rationality behind the expectations regarding economic convergence or catching-up by less developed countries. Also, the critical importance to advance asset valuation methodologies was highlighted concerning all capital assets, in particular, natural capital.

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