Accounting for the inclusive wealth of nations

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1. Introduction

There has been an elusive quest to how we can go beyond gross domestic product (GDP) to reach a true indicator of social well-being. The well-known report by Stiglitz et al. (2009) suggested that GDP has three challenges: conventional problems, quality of life aspects, and sustainability issues. While some argue that GDP is problematic on many fronts, it has its own purposes. It is meant to measure the value added in an economy within a period, and thus to proxy the magnitude of economic activity. Here, it is important to remind that one of the fathers of GDP, Simon Kuznets, originally meant to design an index that represents welfare rather than the value added in an economy (Coyle 2015).

In the vast literature of green national accounting, with reference to long-term well-being of an economy, an adjusted index of GDP – net domestic product (NDP) – has been shown to represent a fair bit of human well-being (Weitzman 1976; Asheim and Weitzman 2001). NDP is computed from GDP, accounting for the change in capital assets such as capital depreciation and natural capital depletion.

It is in this sense that NDP goes some way toward representing human well-being. However, this adjustment is not sufficient for representing intergenerational well-being, or sustainability of an economy. In particular, NDP still includes that portion which is supposed to be allocated to current consumption, which could risk being excessive. Excluding the value of current consumption from NDP leaves us with investment into produced, human, and natural capital --- that is, Inclusive Wealth Index (IWI) (Dasgupta et al., 2015).

What makes our index --- and World Bank's genuine savings --- distinct from GDP is obvious[1]. It

[1] See, UNU-IHDP and UNEP (2012) for what makes inclusive wealth index distinct from World Bank's genuine savings. To be more precise, genuine savings is constructed from flow variables, complemented with stock calculations.

is calculated from stocks, rather than flows; it measures determinants, rather than constituents of well-being (Dasgupta 2001). For the latter, this is more of a matter of subjective well-being such as happiness and life satisfaction (Helliwell et al. 2017, Easterlin 2003, Kahneman et al. 2006, Layard 2005) and other objective outcome of well-being, such as the Better Life Index (OECD 2014). Human Development Index (United Nations Development Programme 1990-2016) is a composite index of education and health, along with GDP, which is a commendable move in that it has shifted focus toward human capital aspects of well-being. Although its original intension is not focused on sustainability, it fails to theoretically associate the index with social well-being; natural capital is also absent, which is an unarguably crucial component in long-term sustainability of nations.

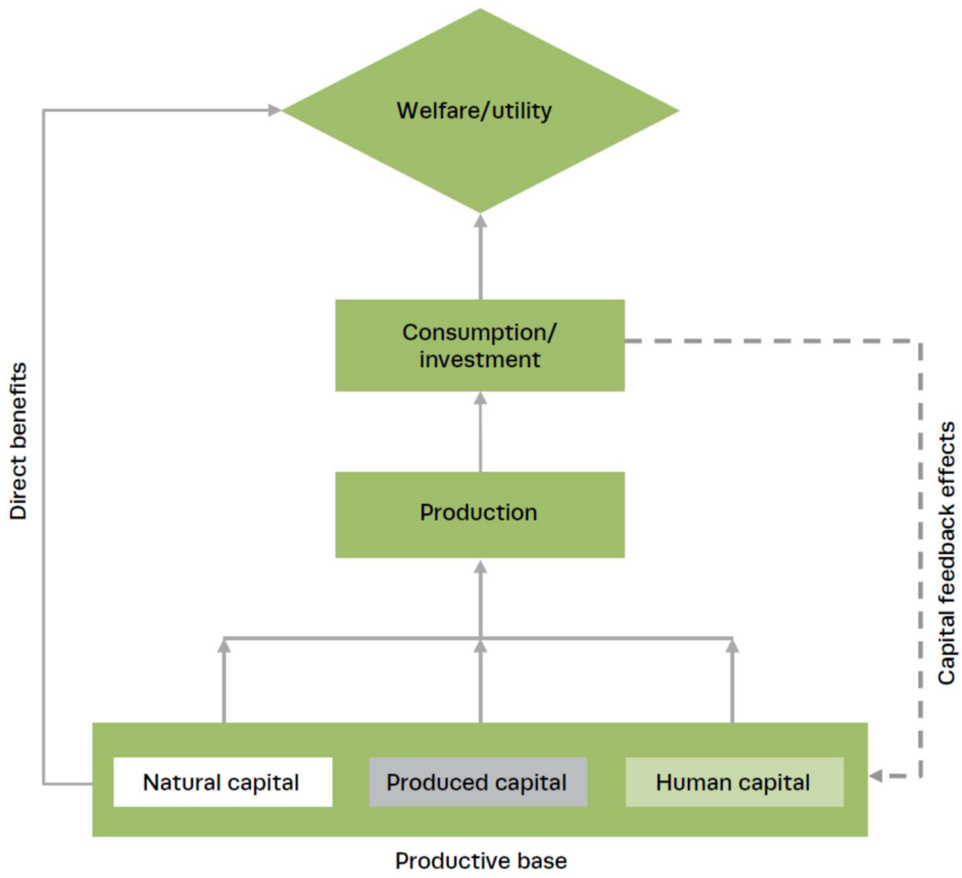
Another strand of literature to leave GDP for a true welfare or well-being indicator is also flourishing. Fleurbaey and Gaulier (2009) ranked OECD countries by accounting for international flows of income, labor, risk of unemployment, healthy life expectancy, household demography and inequalities, along with income. In a similar vein, Jones and Klenow (2016) constructed a welfare index including consumption, leisure, mortality, and inequality fronts, and found that they are highly correlated with GDP per capita but are also deviating. The aspects they address are by no means dismissible; however, our focus is more on long-term sustainability of determinants of human well-being, thereby leading to the construction of a capital-based indicator.

Of course, no single index can measure every aspect of human well-being, and IWI is not an exception in this regard. Note, in particular, that our IWI says little about to what extent *current* well-being is achieved in practice. This is partly due to the fact that the score of current capital stocks is not fully consumed by the contemporaries; it is also because IWI is by construction a determinant- or *opportunity*-based indicator; it is not meant to be something that can explain *outcomes* and constituents of well-being.

In principle, IWI should include a sufficiently broad, ideally exhaustive, but not redundant, score of capital assets that are relevant to current and future human well-being. While classical economics focused on the trio-input of (produced) capital, labor and land, neoclassical economics has treated capital and labor in production function. Then the economics of exhaustible resources included capital and non-renewable resource (Dasgupta and Heal 1974; Solow 1974). In mainstream economics, human capital –capitalized concept of labor – also played an important role in how economic growth can be decomposed (Mankiw et al. 1992). When it comes to sustainable development of well-being, natural capital – a wider notion than just natural resource stock – should not be absent. Thus we have made a full circle to reach the ultimate set of capital stocks as productive base: produced, human, and natural capital.

Figure 1 shows how the three capitals lead to the ultimate purpose—if any—of an economy: social well-being. The three capitals are inputs in the production system, thus they are called the *productive base* of the economy. Produced capital is the easiest to imagine: roads, ports, cables, buildings, machines, equipment, and other physical infrastructures. Human capital consists of population (size and composition), knowledge and skills acquired by education, and health (enhancing the quality of life, extending life, and boosting productivity). For natural capital, the current accounting addresses sub-soil non-renewable resources, forests, agricultural land, but it should ideally include ecosystems in general.

Figure 1: A three-capital model of wealth creation



Along with these familiar three capital assets, our first edition (UNU-IHDP and UNEP 2012) noted that knowledge, population, institutions, and even time can be conceived as capital assets. Dasgupta (2015) calls them enabling assets, in the sense that they enable the three capital assets to function well to improve social well-being. Formally, they could raise the shadow prices of pillar capital assets. All in all, unconventional capitals include the following:

--Institutions (property rights, firms, government, households)

--Knowledge (natural laws, algorithms, theorems, cultural narratives)

--Social capital (the law, social norms, habitual practices)

--Time (exogenous changes experienced by society over time)

While including these capital assets would be commendable, they are at least elusive as it stands. Changing institutions reveal themselves in how capital assets are employed to improve social well-being, and thus could be a determinant of shadow prices of capital assets. Time as an asset represents the value of waiting. This includes Solowian technological progress, resource price movements, population change, and other exogenous shocks to the economy in question. The IWR 2014 and our edition on this IWR2017 address all these terms in the adjustment of IWI, namely, population change, total factor productivity (TFP), oil capital gain, and carbon damage. Thus, time as an asset is already addressed in our framework.

Once we set up relevant capital assets, then the output of this production process is either consumed or invested, as a result of national accounting identity. Current consumption directly improves current well-being, while investment increases accumulation of productive base, which in turn improves future well-being. This fundamental tradeoff between consumption and investment has been a classic problem of optimal saving, dating back at least to Ramsey (1928). But in our context of sustainable development, economies should strike a balance between consumption and investment, the latter including degradation ---negative investment--- of natural capital[2].

Some studies have suggested that there is a direct effect of capital stocks on utility, circumventing the consumption channel. For example, air pollution or climate change can cause disutility, which cannot be substituted by consumption rise (Krautkraemer 1985; Xepapadeas 2005; d'Autume and Schubert 2008). It is not uncommon in the climate change modelling to assume that climate directly affects utility (van der Ploeg and Withagen 2014). It is for these reasons that we have an alternative route from productive base to welfare in Figure 1.

It is of utmost importance to note that the absolute value of wealth *per se* does not mean anything. Only comparison of wealth across time or space (nations) can have welfare significance. Asheim (2010) shows that net national product (NNP) per capita can be most appropriate for the purpose of welfare comparisons across different countries. In any case, we need to resist the temptation to compare the absolute value of inclusive wealth (per capita); our interest should lie in the *change* in inclusive wealth per capita over the course of years.

Building on our first and second editions of IWR, this year's report features several advancements and expansions. First, our rich sample continues to track the 140-country sample of IWR2014, as compared with 20 countries (IWR 2012). The dataset now represents the lion's share of world GDP (56,835 billion) and of global population (6,885 million).

[2] Hartwick (1977) and Dixit et al. (1980) showed that investing exhaustible resource rents into produced capital yields non-declining consumption, which is another way of defining sustainable development.

Second, the studied time period is also expanded by five years to quarter a century, which makes our coverage to the period 1990-2014. This gives us a picture of the change of capital assets almost over a generation.

Third, our dataset of natural capital now includes one of the most significant renewable but mobile resources: fishery. This adds to our collection of renewable resource natural capital which has already included forest resources and agricultural land in IWR2012 and 2014. IWR2012 included some discussion of fishery resources of no more than four countries for the time period 1990–2006, based on the studies of fishery stock (the RAM Legacy Stock Assessment Database (Ricard et al. 2012)) and shadow prices (SAUP 2011). Our edition boasts a much more refined calculation of fish stocks, extended for many countries.

Fourth, the methodologies for calculating components of human capital are enriched and updated. In particular, we present alternative shadow prices of human capital (education and health) based on a non-parametric methodology called frontier analysis. Throughout the report, we call it frontier approach. This is contrasted to the approach adopted in IWR 2012 and 2014, following the literature of pricing human capital by lifetime income approach.

The rest of this introductory chapter is organized as follows. In Section 2, basic idea and methodology behind Inclusive Wealth Index (IWI) is laid out. Further details regarding the architecture of the index are relegated to Methodological Annex at the end of the report. Section 3 presents central results and findings resulting from inclusive wealth calculations, based on non-parametric computation of shadow prices for human capital (education and health). Section 4 shows our parallel results which employ former methods for human capital (education) calculation, which is consistent with traditional interpretation of the rate of return on education and *IWR 2014* results. Section 5 sums up our results, explains some limitations of the current methodology and addresses some concerns and potential criticisms toward IWI in general.

2. Methods

In this section, we outline our underlying framework, which is premised on the body of work in the literature of green accounting, especially under imperfect economies (Arrow et al. 2012). We note that the economy's objective is sustainable development, in the sense that intertemporal well-being at t:

$$V(t) = \int_t^\infty U(C_\tau)e^{-\delta(\tau-t)}d\tau,$$

is not declining. This expression is just a discounted sum of instantaneous welfare that is depicted in Figure 1. A central assumption is that this intertemporal well-being is a function of capital assets in the economy. Thus, denoting produced, human, and natural capital as $K, H,$ and $N,$ we have the following equivalence between inclusive wealth and well-being:

$$W(K,H,N,t) = V(t) = \int_t^{\infty} U(C_\tau) e^{-\delta(\tau - t)} d\tau,$$

where W is inclusive wealth. Then sustainable development is equivalent to non-declining inclusive wealth. Formally, we would like to make sure the sign of the temporal change of inclusive wealth:

$$\frac{dW(K,H,N,t)}{dt} = p_K \frac{dK}{dt} + p_H \frac{dH}{dt} + p_N \frac{dN}{dt} + \frac{\partial V}{\partial t},$$

where p_K, p_H and p_K are the marginal shadow prices of produced, human, and natural capital, respectively. Note that, aside from the three-capital channel, we have a direct channel through which just a passing of time directly affects well-being. The shadow prices are essentially marginal contributions to intertemporal well-being of an additional unit of capital in question. They are formally defined by

$$p_K \equiv \frac{\partial V}{\partial K}, p_H \equiv \frac{\partial V}{\partial H}, p_N \equiv \frac{\partial V}{\partial N},$$

given a forecast of how produced, human, and natural capitals, as well as other flow variables, evolve in the future in the economy in question. In practice, shadow prices act as a weight factor attached to each capital, resulting in the measure of wealth, or IWI:

$$IWI = p_K K + p_H H + p_N N.$$

In practice, we can use W and IWI interchangeably[3]. For sustainability analysis, what we need is the change in capital assets, or what we may call inclusive investment,

$$\frac{dW(K,H,N,t)}{dt} = p_K \frac{dK}{dt} + p_H \frac{dH}{dt} + p_N \frac{dN}{dt} + \frac{\partial V}{\partial t}.$$

In our accounting, barring oil capital gains we will elaborate later, we leave out the change in the shadow prices for both theoretical and practical reasons. Shadow prices are defined as the marginal changes when there is a hypothetical small perturbation in capital assets. Thus, for tracking relatively short-term sustainability, it suffices to use fixed, average shadow prices within the studied period. It also makes practical sense in our report, since fixing shadow prices will enable us to focus on the quantity change in inclusive wealth.

In addition, if there is a large perturbation, such as a large project implementation, natural disasters, or financial crisis, we need to account for the change in shadow prices even within a short time period. We might take the price change –capital gains on any capital asset -- seriously , as we will accumulate our editions of IWR over the course of the years ahead.

One exception of this rule of constant shadow prices assumed over the studied period is the oil

[3] In theory, W is different from IWI, which is calculated based on constant shadow prices. When reckoning the real W, it is obvious that, say, the last drop of oil should have a different marginal value than the regular drop when it is not scarce. We compute IWI on the premise that the studied period is relatively short.

capital gains. Oil prices, or commodity prices for that matter, are notorious for fluctuations within relatively short period of time. Even if the physical quantity of an oil rich nation does not change, a spike in the oil price will translate into better opportunities for the country, as they can cash in their oil wealth in the market for increased consumption and investment into inclusive wealth. This is particularly relevant for oil-rich nations in the Middle East where economic powerhouse other than oil-related industries has long been craved. Nurturing an industry from scratch takes a long time. On the flip side, net oil importing countries tend to witness their social well-being degraded by rising oil prices. We account for this loss of opportunity by allocating the global oil capital gains to oil-importing countries according to the current share of oil imports. Formally, if we allow the shadow price of natural capital p_N to change, we have

$$\frac{\partial V}{\partial t} = p_N N \frac{dp_N/dt}{p_N},$$

which represents our capital gain adjustment.

Aside from this oil capital gains, there is another class of adjustment contributed by our enabling assets we mentioned earlier. How capital assets are employed and utilized to yield ultimate social well-being may change over time. This might be the enhanced productivity of activities, technological progress, or improvement in trust and social capital. In practice, however, all of these should be captured by the change in TFP. In so far as social well-being improves (deteriorates) more than individual contribution of capital assets increase (decrease), this residual should also be accounted for. Arrow et al. (2012) have shown that what needs to be done in accounting is just to add TFP growth rate to inclusive wealth growth rate.

Finally, there is another aspect of the natural environment that need not be dismissed in the coming centuries. Increasing carbon emissions are likely to cause climate change, which endangers many lives, as well as other potentially devastating socioeconomic damages. It can be conceivably stated that the current economic activity is reducing the carbon sink stock of our planet, which can be accounted for as another capital asset in inclusive wealth. Alternatively, we can tap into the ongoing and increasing research on the social cost of carbon to be employed to value the damage done to social well-being by an additional emission of carbon. In this report, we continue to adopt the latter approach. In particular, the total global emission of carbon is evaluated using the social cost of carbon, which is then allocated to individual countries according to the share of the global damage done, which is further subtracted from inclusive wealth of nations[4].

Figure 2 provides our schematic representation of how our three-pillar capital assets as well as adjustment factors shape our final index of inclusive wealth. Along with the familiar capital assets we have been accounting for from previous reports (IWR2012&2014), this report adds fishery resource

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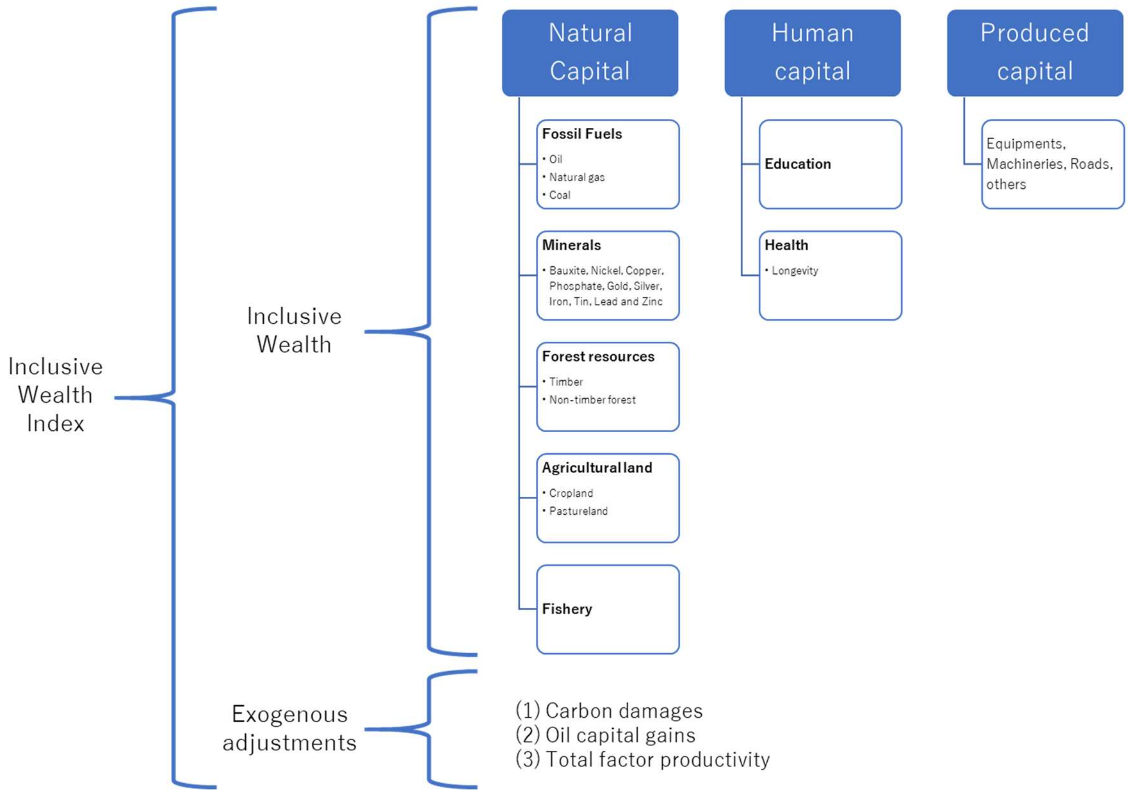
[4] More specifically, the share of carbon damage to inclusive wealth can be deducted from the inclusive wealth growth rate, to arrive at the adjusted inclusive wealth growth rate.

stock to the list of natural capital. In the ensuing sections, we report many aspects of the aggregated figures of inclusive wealth index, both before and after adjustments.

To avoid confusion, in Section 3, we focus on inclusive wealth based on frontier approach, which uses a non-parametric valuing of education- and health-induced human capital. Produced and natural capital are computed in a similar way as in IWR 2012 and 2014. In Section 4, we extend the conventional approach inherited from IWR2012 and 2014. For human capital, we only account for education-induced portion. For further notes on the different methodologies, readers are advised to examine Methodological Annex.

Figure 2: Schematic representation of the Inclusive Wealth Index and the Adjusted Inclusive Wealth Index



3. The inclusive wealth of nations

3.1. Measuring performances based on changes in wealth

In this subsection, we evaluate the countries sustainability condition over the past 25 years, based on calculating human capital including both education and health shadow prices by frontier approach. The sustainable growth of the nations is evaluated by analyzing changes of IWI. We show the changes in inclusive wealth, both in absolute and per capita forms, for 140 countries over the past few decades. In addition, we discuss how the changes and per capita changes of wealth correlate with other traditional indicators.

The results show that the growth of inclusive wealth of the nations is positive for a considerable number of countries. However, the slower progress of wealth than the population growth results in negative per capita growth of wealth for a significant number of countries as well. In addition, some of the negative per capita growth of wealth countries experienced absolute gains in wealth. The changes of countries' wealth calculated by annual average growth rates over past 25 years and 1990 is set as a base year.

Our estimation results show that 135 of 140 countries assessed in the IWR 2017 present a growth of Inclusive Wealth (before adjusted factors) (Figure 3 a). On a per capita basis, 89 of 140 countries (64%) showing positive growth rates in IW (Figure 3 b).

Figure 3: Annual average growth rate in IW and IW per capita before adjustments for 140 countries, annual average for 1990-2014

Figure 3 a: Annual average growth rate of Inclusive Wealth, before adjustments

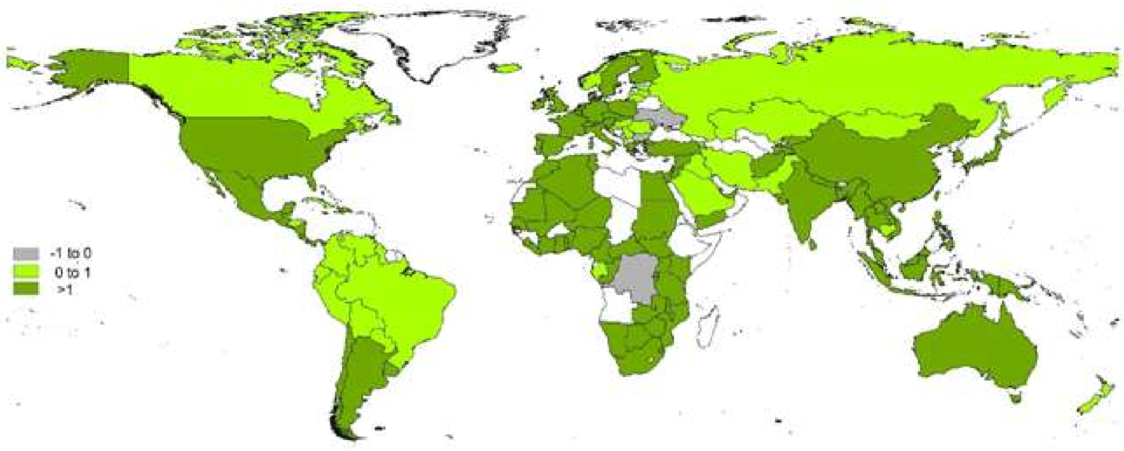
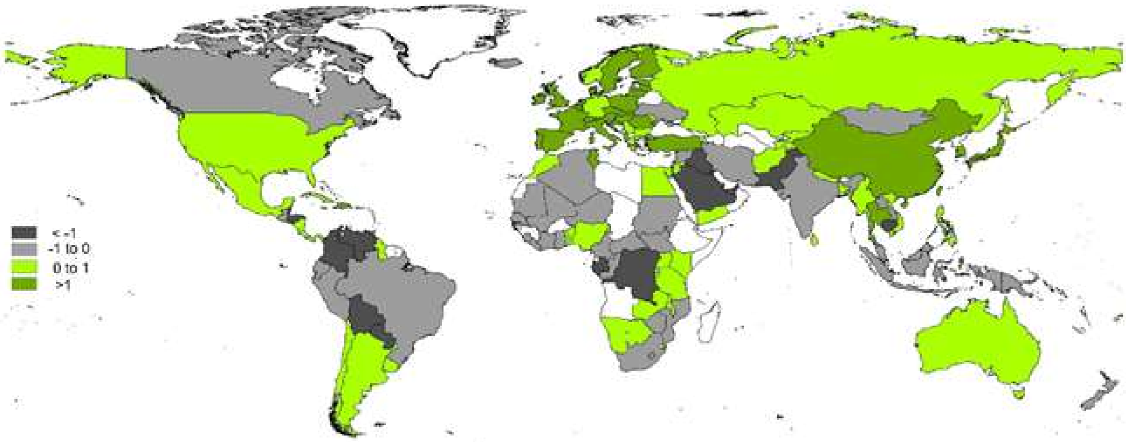


Figure 3 b: Annual average growth rate of Inclusive Wealth per capita, before adjustments



When IW include the adjustments of TFP, carbon damages and oil capital gains to evaluate social well-being, 124 of 140 countries shows positive growth rate (Figure 4 a). In a per capita analysis, 96 of 140 countries (69%) experienced positive IW growth rates after adjustments (Figure 4 b).

Figure 4: Annual average growth rate in IW and IW per capita after adjustments for 140 countries assessed in the IWR 2017 during the period 1990 and 2014

Figure 4 a: Growth in Inclusive Wealth (adjusted)

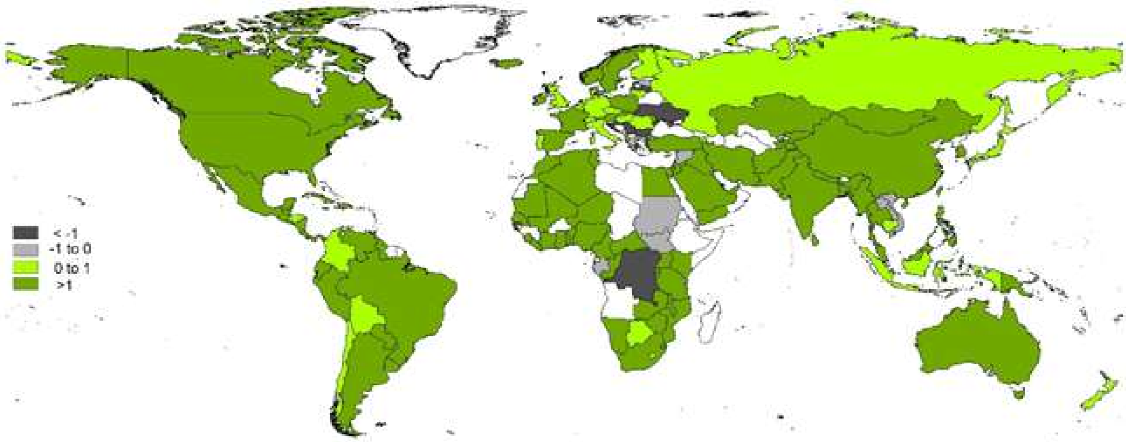
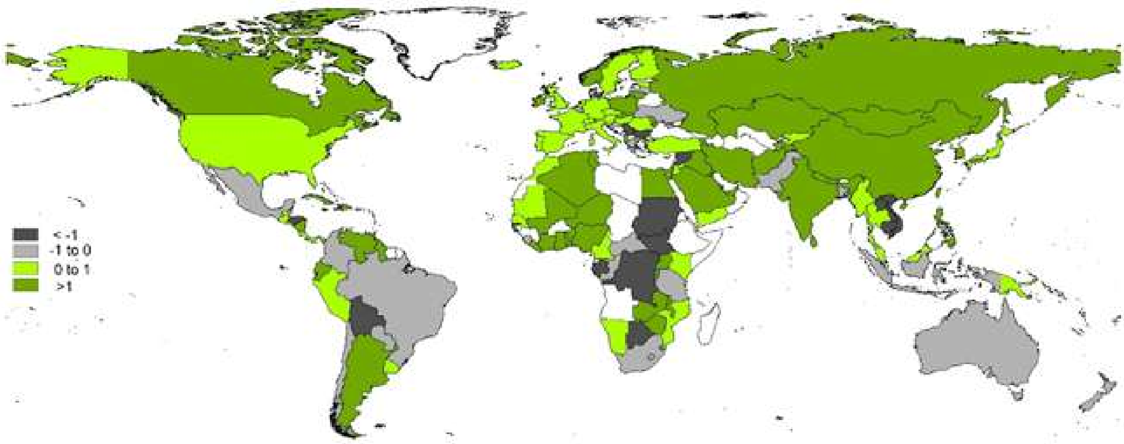


Figure 4 b: Growth in Inclusive Wealth per capita (adjusted)

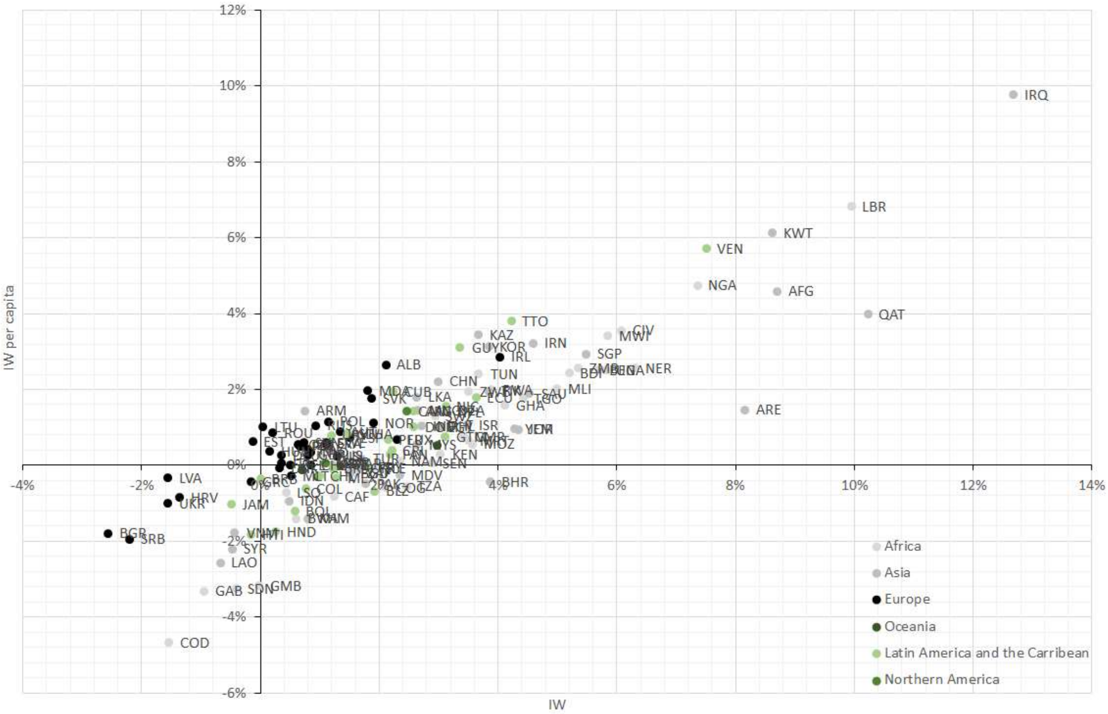


We investigate the IW growth by identifying countries and regions in Figure 5a. Three countries can be identified in Quadrant III: Congo, Trinidad and Tobago, and Ukraine have experienced negative growth rates in both absolute and per capita terms. Two former Soviet countries – Bulgaria and Moldova – *improved* their performance when population is considered in the index, because both countries have been under declining population over time (Quadrant II of Figure 5a). Population reduces in these countries and mare resources become available for persons compared to the base year. Out of 135 countries with positive absolute growth in wealth (Quadrant I and IV), 87 also experienced per capita growth in wealth as well (Quadrant I). The remaining 48 countries which have seen a decline in wealth on a per capita basis (quadrant IV) can be regarded as underinvesting in wealth in light of their population growth.

We identify the IW growth rate of countries in addition to the three adjustments of IW in Figure 5 b. Fifteen countries are assessed as unsustainable by IW per capita adjusted: Bulgaria, Congo, Gabon, Gambia, Greece, Croatia, Haiti, Jamaica, Laos, Latvia, Sudan, Serbia, Syria, Ukraine, and Vietnam. Both absolute and per capita terms are showing negative growth rate in Quadrant III of Figure 5 b. Estonia is the only country which improved when population is considered (Quadrant II). Out of the 124 countries with positive absolute growth in inclusive wealth adjusted (Quadrant I and IV), 95 countries also experience growing wealth per capita (Quadrant I). Remaining 29 countries have eroded wealth on a per capita basis.

Figure 5 a: Annual average growth rate in IW and IW per capita (unadjusted)

Figure 5 b: Annual average growth rate in IW and IW per capita (adjusted)

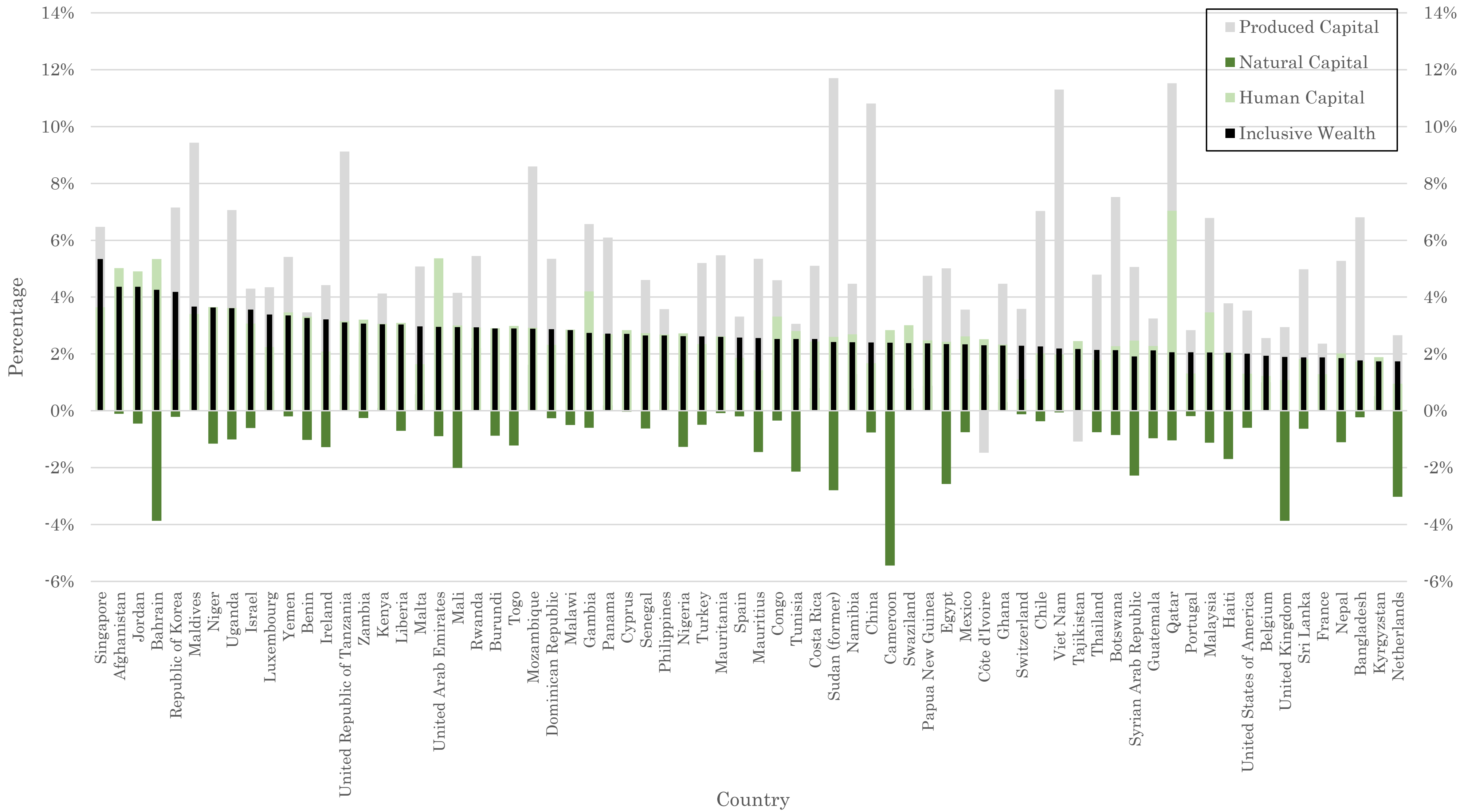


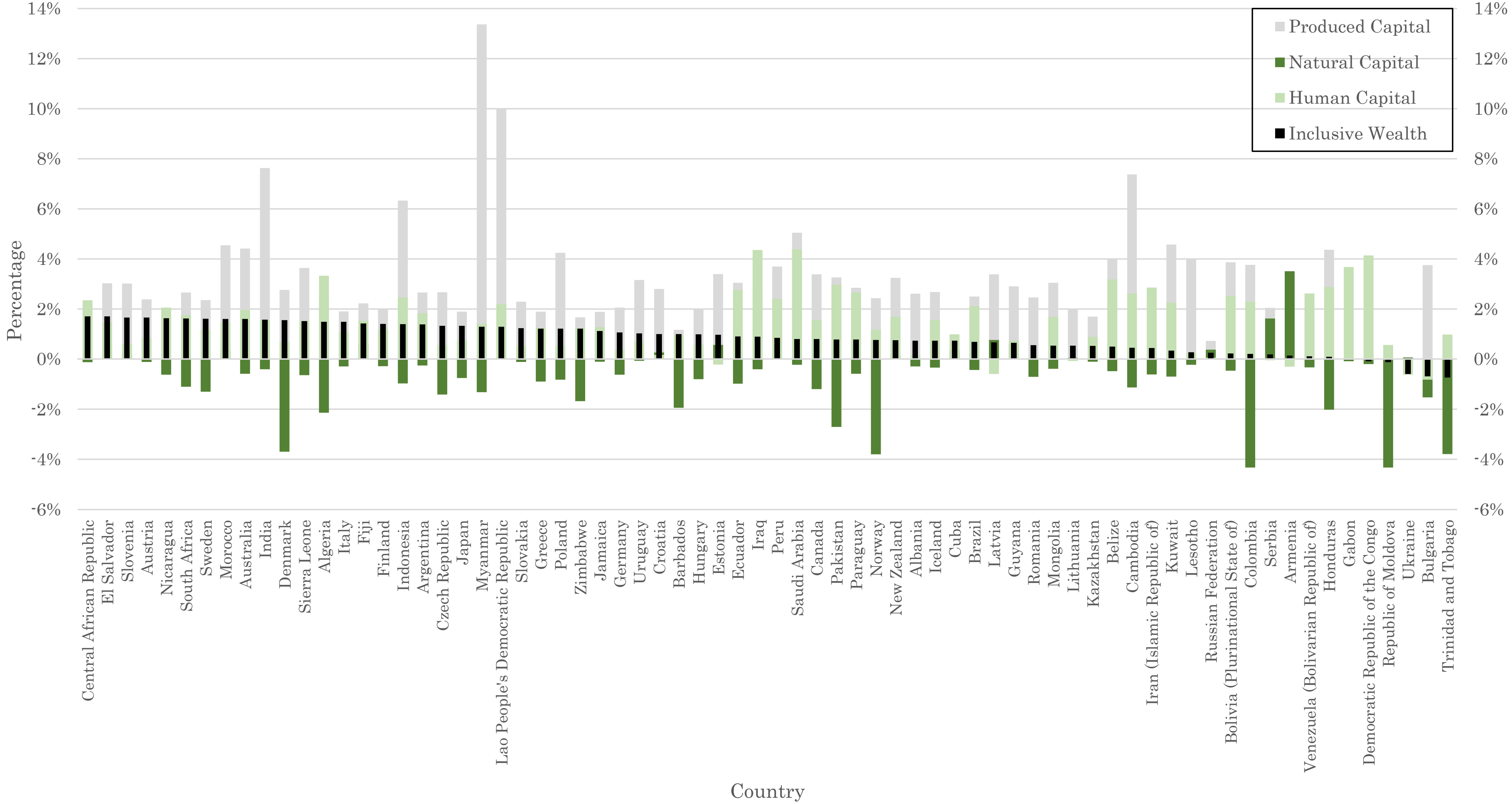
3.2. Wealth change compositions

In this section, we break down inclusive wealth change by the contribution of capital assets. Contributions of natural, human, and produced capital in average inclusive wealth growth are shown in Figure 6. It has to be noted that natural capital has been positive for only 31 countries. In contrast, in 133 nations, human capital increased during the period between 1990 to 2014; for produced capital, 136 of 140 countries gained.

On a per capita front, positive growth in human capital is achieved by 122 countries. Similarly, 120 of 140 nations experienced growth for produced capital from 1990 to 2014. The contribution of human capital has been 59% over 1990-2014, followed by produced capital (21%) and natural capital (20%). For the breakdown of human capital, 33% and 26% come from education and health, respectively.

Figure 6: IW growth rates disaggregated by capital form, annual average for 1990-2014

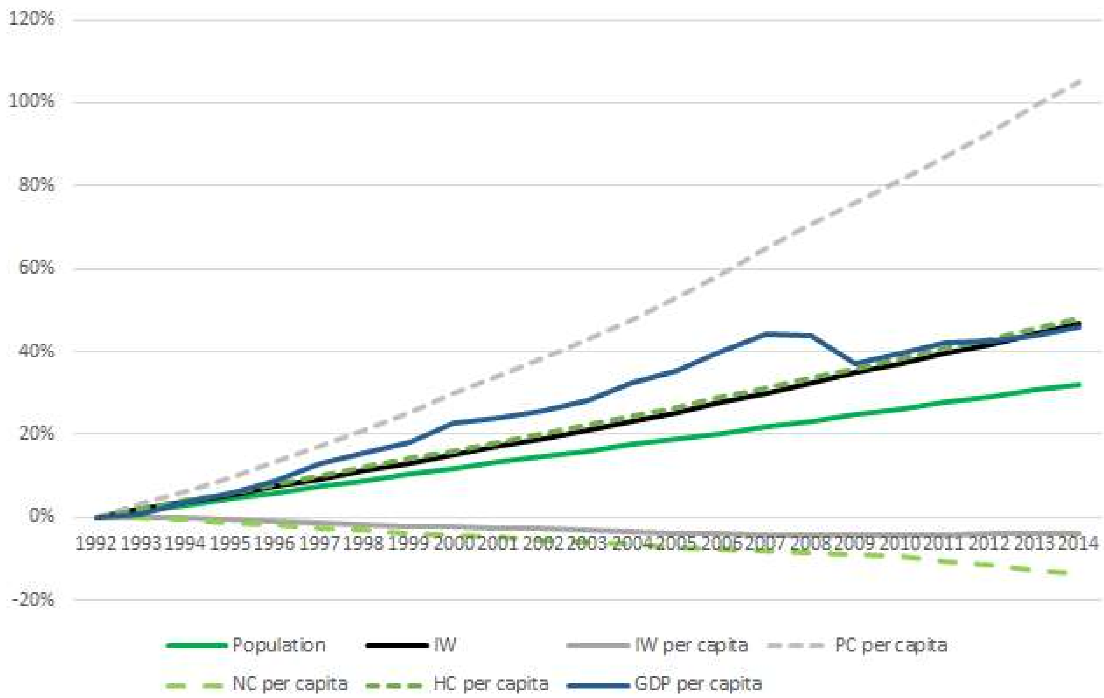




Produced Capital
Natural Capital
Human Capital
Inclusive Wealth
Percentage
14%
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
-6%
Country
Central African Republic
El Salvador
Slovenia
Austria
Nicaragua
South Africa
Sweden
Morocco
Australia
India
Denmark
Sierra Leone
Algeria
Italy
Fiji
Finland
Indonesia
Argentina
Czech Republic
Japan
Myanmar
Lao People's Democratic Republic
Slovakia
Greece
Poland
Zimbabwe
Jamaica
Germany
Uruguay
Croatia
Barbados
Hungary
Estonia
Ecuador
Iraq
Peru
Saudi Arabia
Canada
Pakistan
Paraguay
Norway
New Zealand
Albania
Iceland
Cuba
Brazil
Latvia
Guyana
Romania
Mongolia
Lithuania
Kazakhstan
Belize
Cambodia
Iran (Islamic Republic of)
Kuwait
Lesotho
Russian Federation
Bolivia (Plurinational State of)
Colombia
Serbia
Armenia
Venezuela (Bolivarian Republic of)
Honduras
Gabon
Democratic Republic of the Congo
Republic of Moldova
Ukraine
Bulgaria
Trinidad and Tobago

The global change of inclusive wealth in absolute and per capita terms is critical to evaluate the performance of the global economy. We calculate the changes of inclusive wealth and per capita inclusive wealth into international dollars using purchasing power parity (PPP) exchange rates. This data is the aggregated wealth of all the nations for the time 1992 to 2014, and results are illustrated in Figure 7. Changes in global wealth were significantly positive throughout 1990 to 2014. The major positive changes can be observed for produced capital, which is followed by human capital. On the contrary, natural capital experienced a significant decline from 1992.

Figure 7: Changes in worldwide inclusive wealth per capita and other indicators for 1992-2014



3.3. Wealth compositions

In this section, we discuss the wealth stock of nations by sources. Compositions of the assets of countries are shown in Figure 8, representing the relative importance of each capital. Human capital is dominant over other two capitals for 93 out of 140 countries evaluated. In addition, the majority (77) of those 93 countries owned 50 percent or higher share of human capital than natural and produced capital.

Turning to natural capital, it turned out to be the most important source of wealth for 21 countries. Interestingly, 16 out of 21 natural-capital abundant nations are low income or middle-income economy.

South America, Middle Africa and Western Asia are the regions where natural capital are important source of wealth.

For 19 countries, produced capital is the main source of capital. Of those nations with a lion share of produced capital in composition, all are high income countries and geographically located in Europe, North America, and East Asia.

Figure 8: Percentage of human, produced, and natural capital in total wealth, annual average for 1990-2014

Figure 8 a: Percentage of natural capital in total wealth

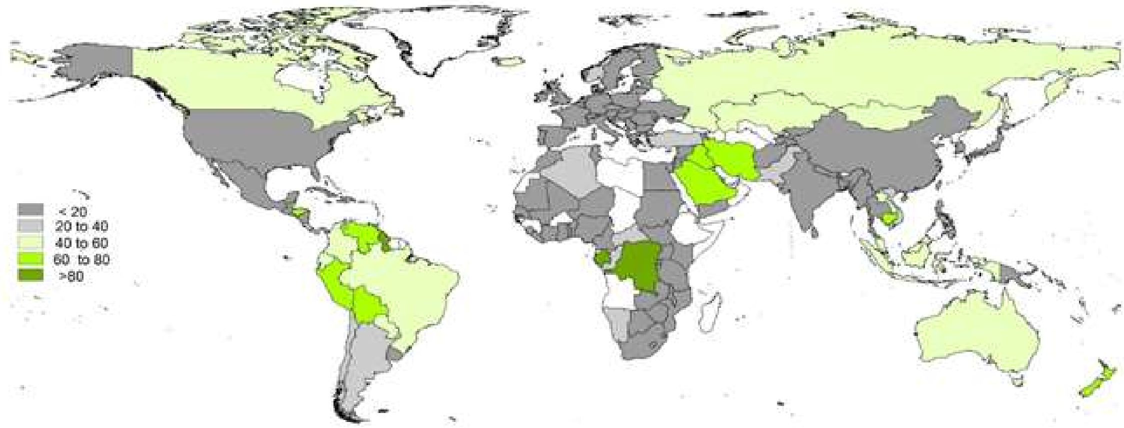


Figure 8 b: Percentage of produced capital in total wealth

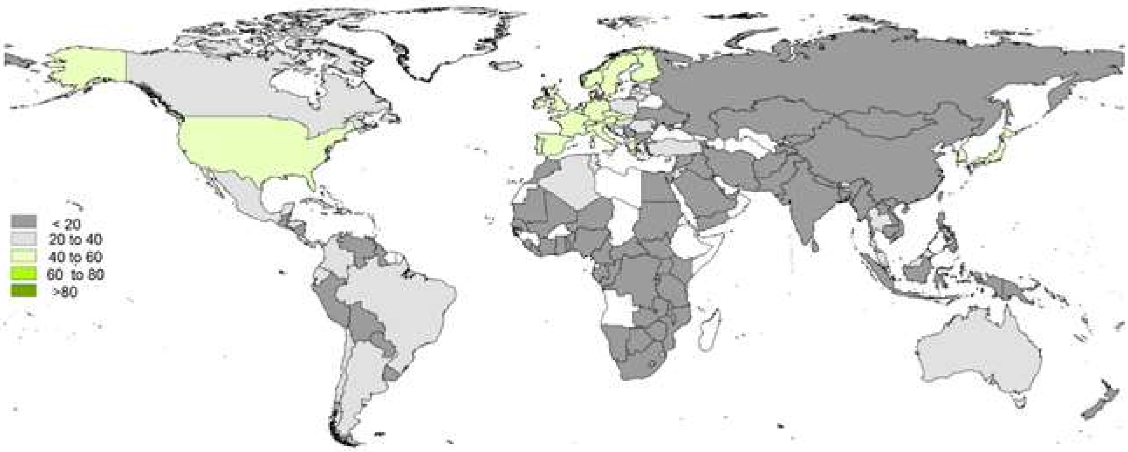
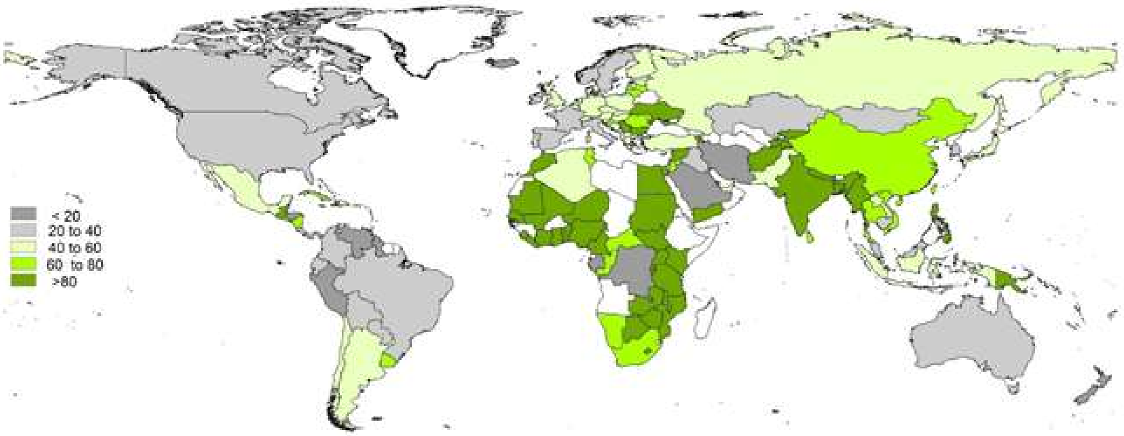


Figure 8 c: Percentage of human capital in total wealth



We also explore how the overall capital is composed on the global level. The share of human capital clearly demonstrates its importance, with a representation of 59 percent (Figure 9a). Developments of the capitals over time show that, while the average contribution of human and produced capital to the total capital increased, the natural capital share has declined, as symbolically expressed in the crossing line of Figure 9b.

Figure 9: Developments in the composition of wealth by capital from 1990-2014

Figure 9a: Average wealth compositions across countries (mean 1990-2014)

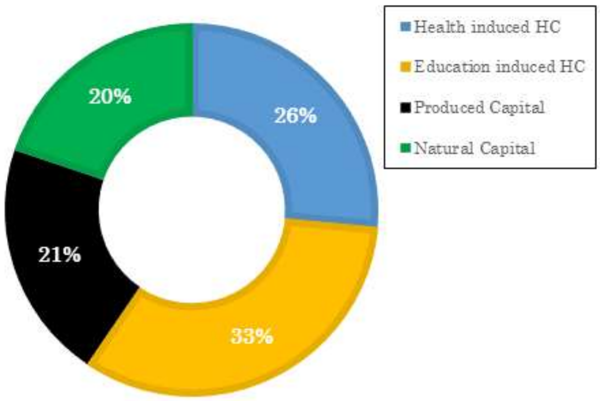
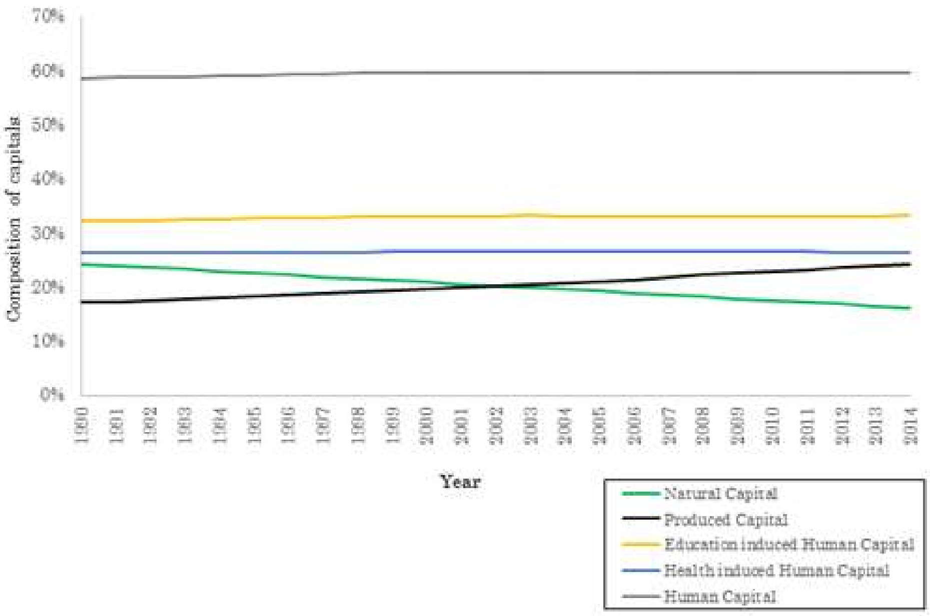


Figure 9 b: Developments in the country average wealth composition



An interesting composition between human and natural capital can be observed in Figure 10 a: countries with high share of human capital generally have a lower share of natural capital. As expected, high income countries also tend to have a higher share of produced capital and a low share in natural capital (Figure 10b). Moreover, high income countries have a balanced share of human and produced capital (Figure 10c). These shares should be interpreted with caution, though, as they just show the worth of one capital in relation to total wealth of the country.

Figure 10: Percentage share of capital in total wealth, average 1990-2014

Figure 10a: Percentage share of human capital and natural capital in total wealth

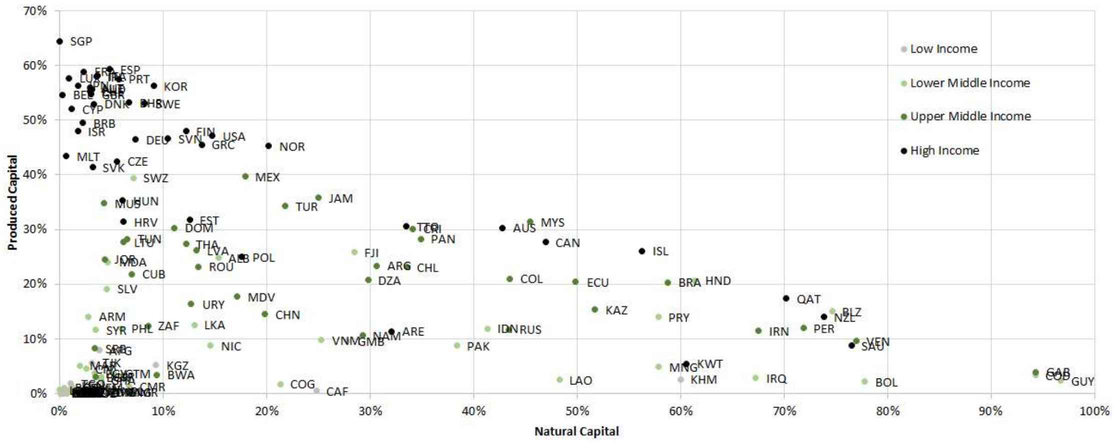


Figure 10 b: Percentage share of produced capital and natural capital in total wealth

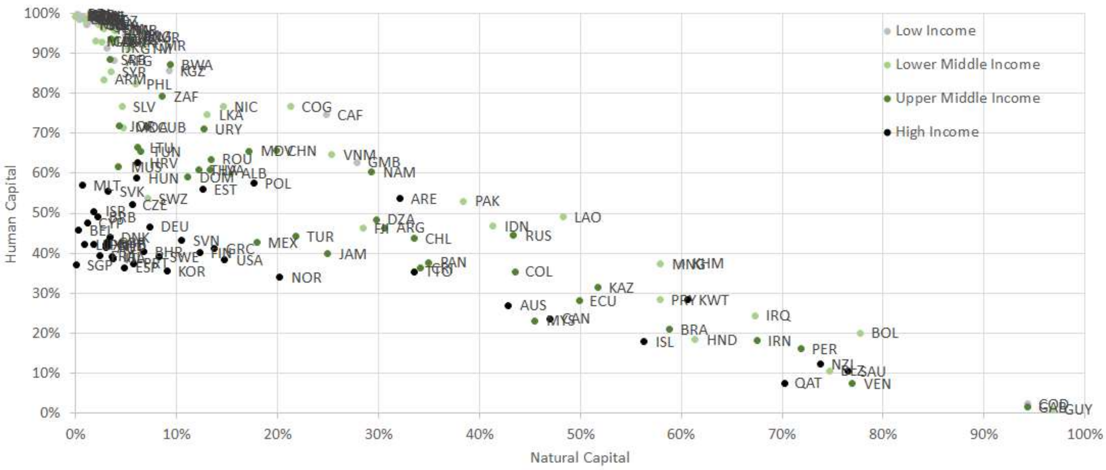
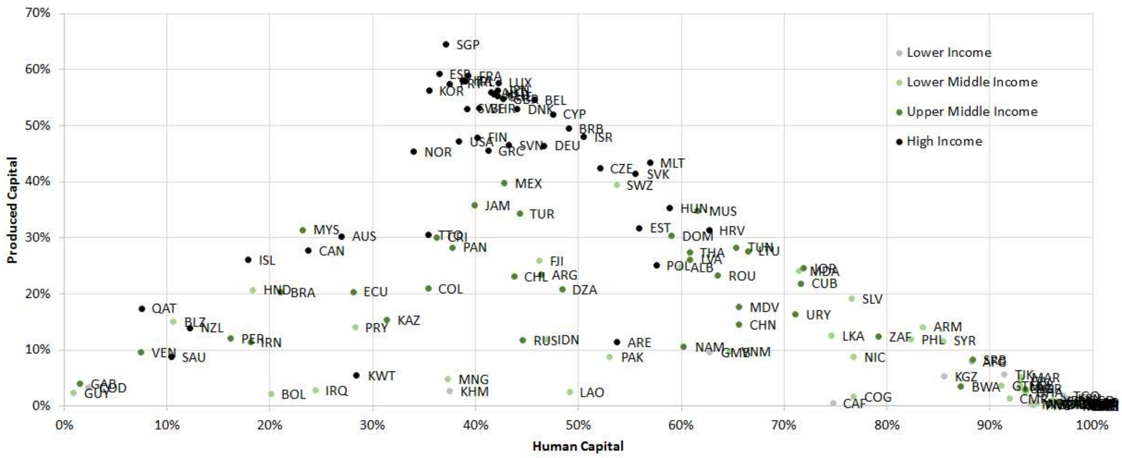


Figure 10 c: Percentage share of produced capital and human capital in total wealth



3.4. IWI adjusted

In this subsection, we investigate the performance of IW, after taking the three factors into account:

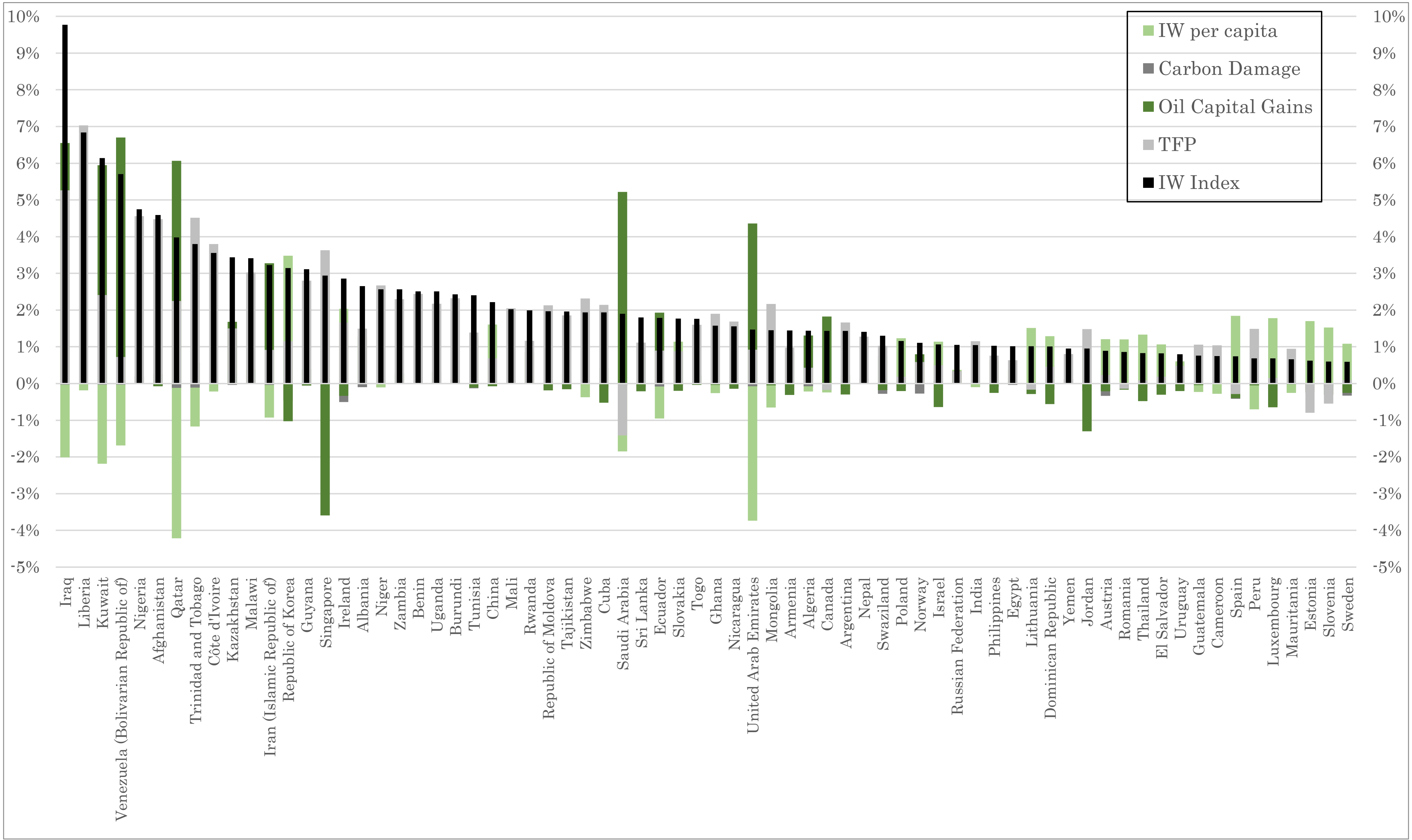
1. Carbon damages: accounting for damages by climate change, which are experienced by nations due to increased impact of carbon concentration in the atmosphere.
2. TFP: explaining the exogenous factors which are missing but impacting on economic growth.
3. Oil capital gains: capturing the changes in oil price and how the value of productive base changes.

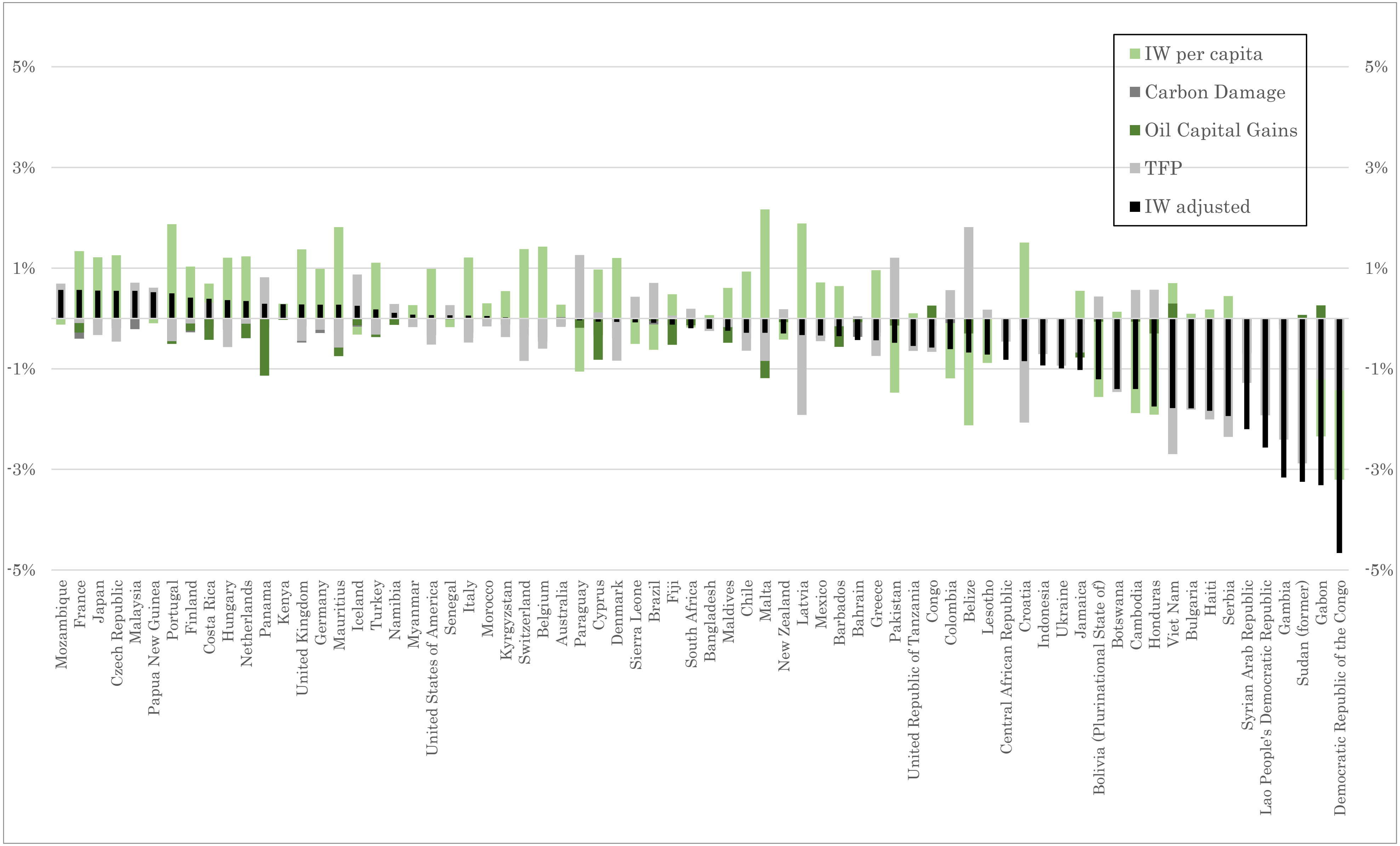
The adjustment factors can affect the IW of nations either positively or negatively. If oil price increase, oil producing countries benefit, while oil importing countries experience loss. TFP can also impact either way, less efficient use of resources will cause negative productivity in the following year. In Figure 11, we show estimates of how each of the adjustment factors contributes to IW of nations. We plot the adjusted IW in a gradually decreasing order for identifying the impacts on countries.

In our analysis, Moldova and Trinidad and Tobago are the "gainers" by adjustments; they moved from negative to positive IW growth rates. In contrast, 13 countries have reported positive growth in IW but turned to negative IW growth after adjustments[5]. In per capita terms before adjustments, 89 countries experienced positive growth in IW; after adjustments, the number of countries with positive growth in IW per capita increased to 98 countries.

[5] These are Estonia, Gabon, Gambia, Greece, Croatia, Haiti, Jamaica, Laos, Latvia, Sudan, Serbia, Syria and Vietnam.

Figure 11: Average annual growth rates of IWI disaggregate by the three adjustments





IW per capita
Carbon Damage
Oil Capital Gains
TFP
IW adjusted
5%
3%
1%
-1%
-3%
-5%
Mozambique
France
Japan
Czech Republic
Malaysia
Papua New Guinea
Portugal
Finland
Costa Rica
Hungary
Netherlands
Panama
Kenya
United Kingdom
Germany
Mauritius
Iceland
Turkey
Namibia
Myanmar
United States of America
Senegal
Italy
Morocco
Kyrgyzstan
Switzerland
Belgium
Australia
Paraguay
Cyprus
Denmark
Sierra Leone
Brazil
Fiji
South Africa
Bangladesh
Maldives
Chile
Malta
New Zealand
Latvia
Mexico
Barbados
Bahrain
Greece
Pakistan
United Republic of Tanzania
Congo
Colombia
Belize
Lesotho
Central African Republic
Croatia
Indonesia
Ukraine
Jamaica
Bolivia (Plurinational State of)
Botswana
Cambodia
Honduras
Viet Nam
Bulgaria
Haiti
Serbia
Syrian Arab Republic
Lao People's Democratic Republic
Gambia
Sudan (former)
Gabon
Democratic Republic of the Congo

We examine contributions of the specific adjustment factors. Regarding carbon damage incurred by climate change, 134 of 140 countries face negative economic impact. Only six countries improve the productive base and avoid the adverse impact of climate change damages. However, its impact is less than 0.5 percent of IW per capita adjusted, which can be said relatively low.

Oil capital gains show that 113 of 140 countries suffer from increasing price of oil. Remaining 27 countries experience positive impact of oil price increase. Six oil-abundant countries mainly in the Middle East, for instance, gain at least 4 percent from increasing oil price: Venezuela, Iraq, Qatar, Kuwait, Saudi Arabia and United Arab Emirates.

Finally, TFP growth rates have been positive for 87 countries; negative for 53 countries. The average growth of TFP range from +7 percent to -3 percent and have significant impacts on several countries. For instance, Malaysia moved to positive growth of per capita IW adjusted, primarily due to positive TFP growth. In contrast, Serbia moved to negative IW per capita adjusted, mainly for negative changes in TFP.

Figure 12: Annual average growth of the adjustment factors from 1990-2014

Figure 12 a: Average growth rate of oil capital gains from 1990-2014

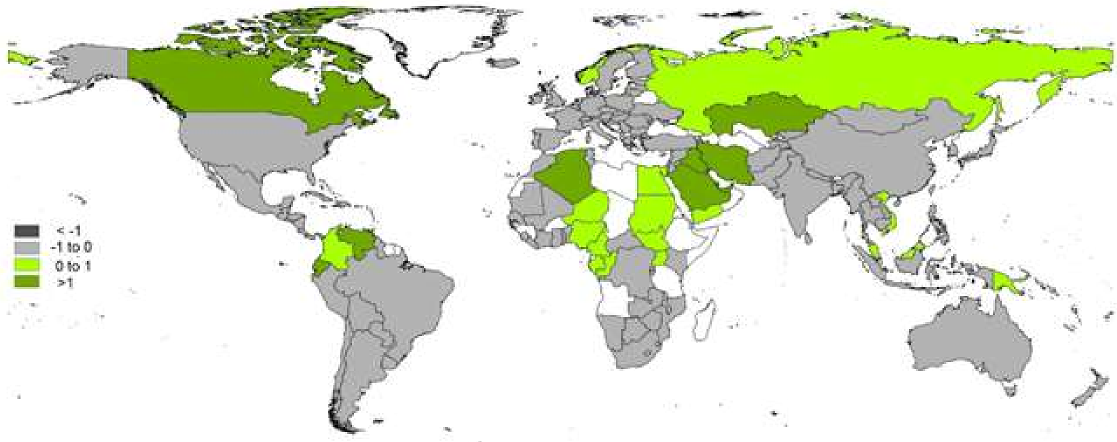


Figure 12 b: Average growth rate of Total Factor Productivity (TFP) from 1990-2014

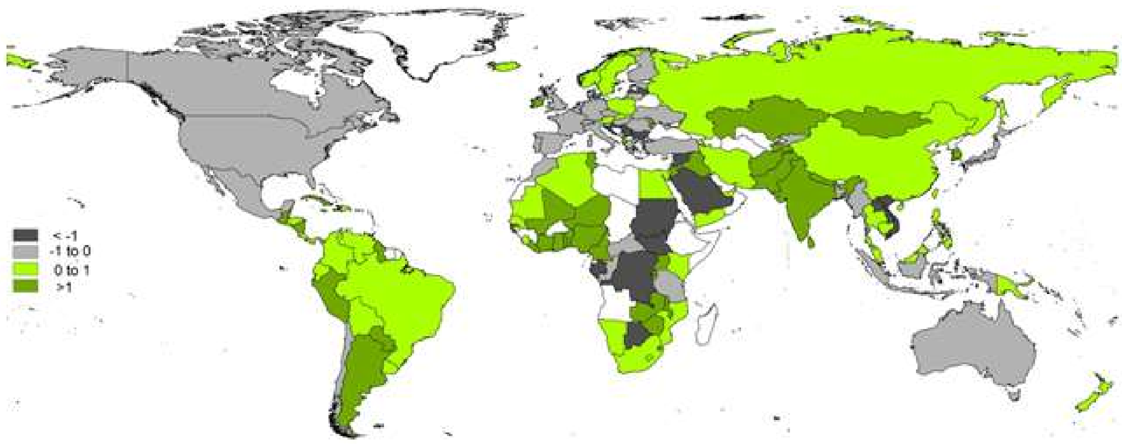
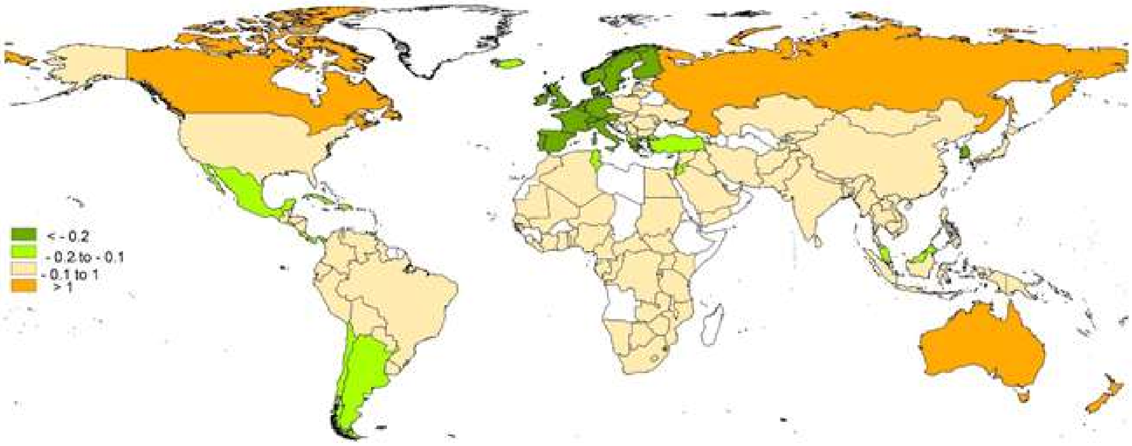


Figure 12c: Average growth rate of Carbon Damages from 1990-2014



3.5. Measuring economic performance: comparison of inclusive wealth, GDP, HDI and Happiness

For evaluation of the nations' economic and social performance, there exist a number of indicators. Three of the commonly used indicators are gross domestic product (GDP), Human Development Index (HDI), and Happiness. GDP is the indicator to measure the market value of final goods and services in an economy over a period. HDI measures the well-being of the nations by considering education, life expectancy and income. Happiness, although measured in many ways, basically evaluate the people's subjective satisfaction by considering freedom, social support, life expectancy, corruption, among others. Figure 13 provide an overview of countries GDP per capita, HDI and inclusive wealth per capita in terms of annual average growth rate over the period 1990 to 2014.

Figure 14a provides the relationship between the growth of HDI and IW per capita. We find a positive growth of IW per capita for 89 countries and negative growth for 51 countries. Figure 14b represents the growth of HDI and adjusted IW per capita. We identify positive growth of IW for 97 countries, while in the case of HDI, 139 of 140 countries show positive growth. Thus, the IW per capita shows more pessimistic picture of progress of nations than HDI. In terms of GDP, 128 of 140 countries indicate positive growth rate over the past 25 years; the rest of them are mostly African nations (Figure 15a and b). This is evidently a dissimilar picture shown by IWI or even other indicators of sustainability.

As GDP, HDI, and IWI do not represent the same – if not totally different – aspect of human well-being, the evaluation of the countries is not always consistent among the three. We note, however, that when the nations are grouped in high income or developed economies, all the three measures consistently show a positive growth rate. In addition, the measure of happiness also shows a high satisfaction level (not growth) in developed countries (Figure 17a and b).

Figure 13: Average annual growth rates of IW per capita, GDP per capita, and HDI, period 1990-2014

Figure 13a: IW per capita

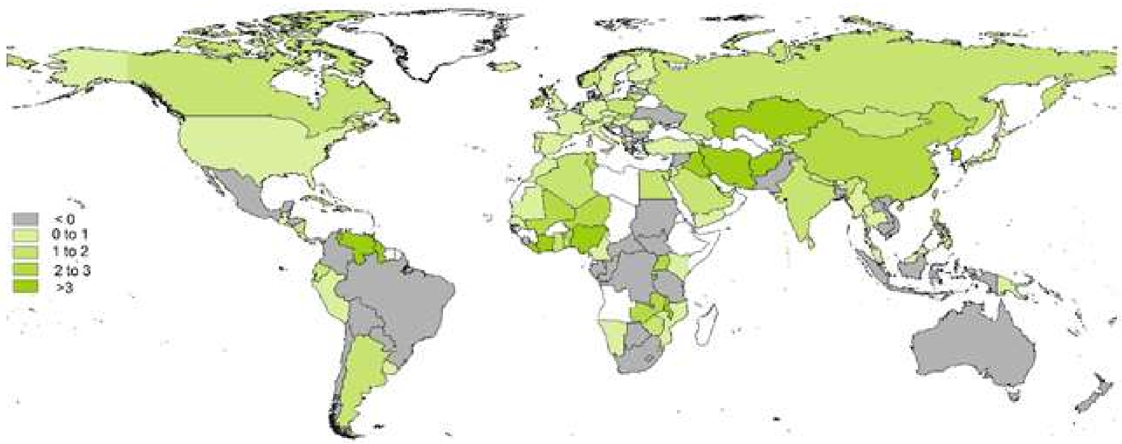


Figure 13b: GDP per capita

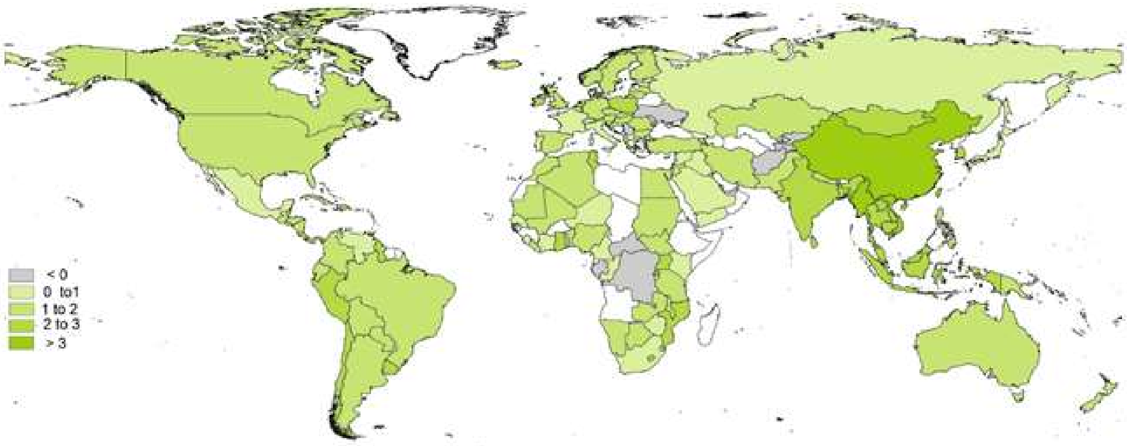


Figure 13c: HDI

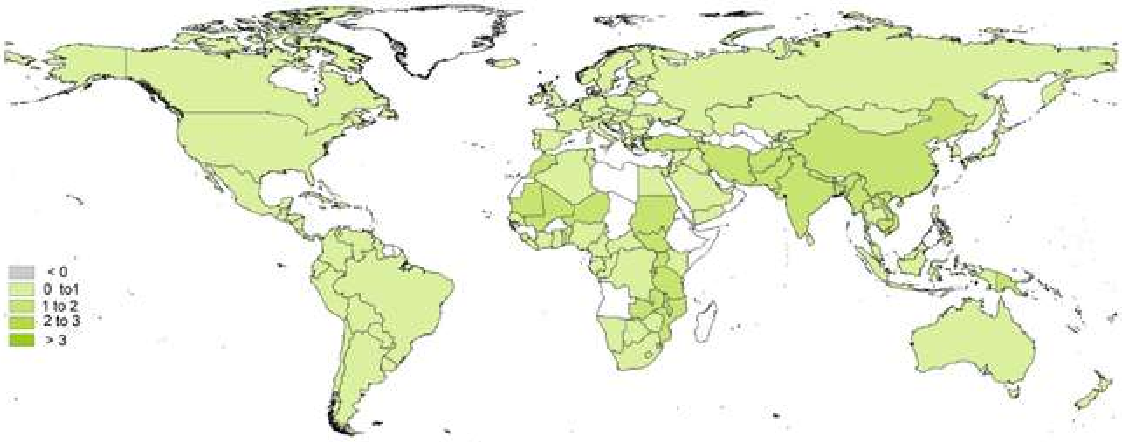


Figure 14a: HDI vs. IW per capita (before adjustments)

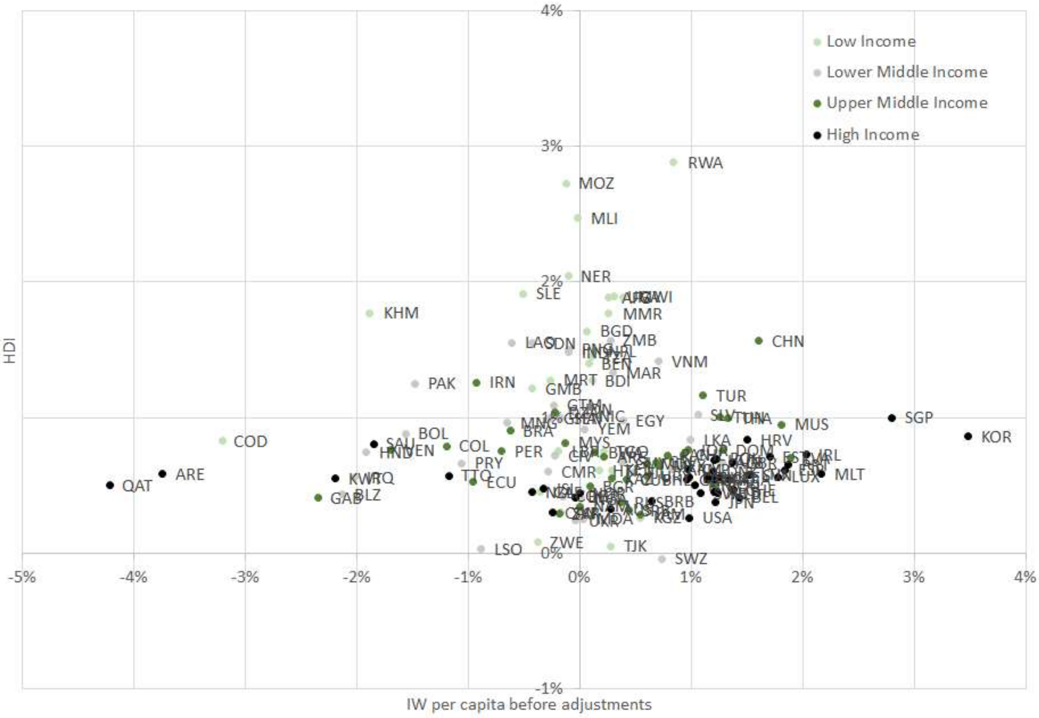


Figure 14b: HDI vs. IW per capita adjusted

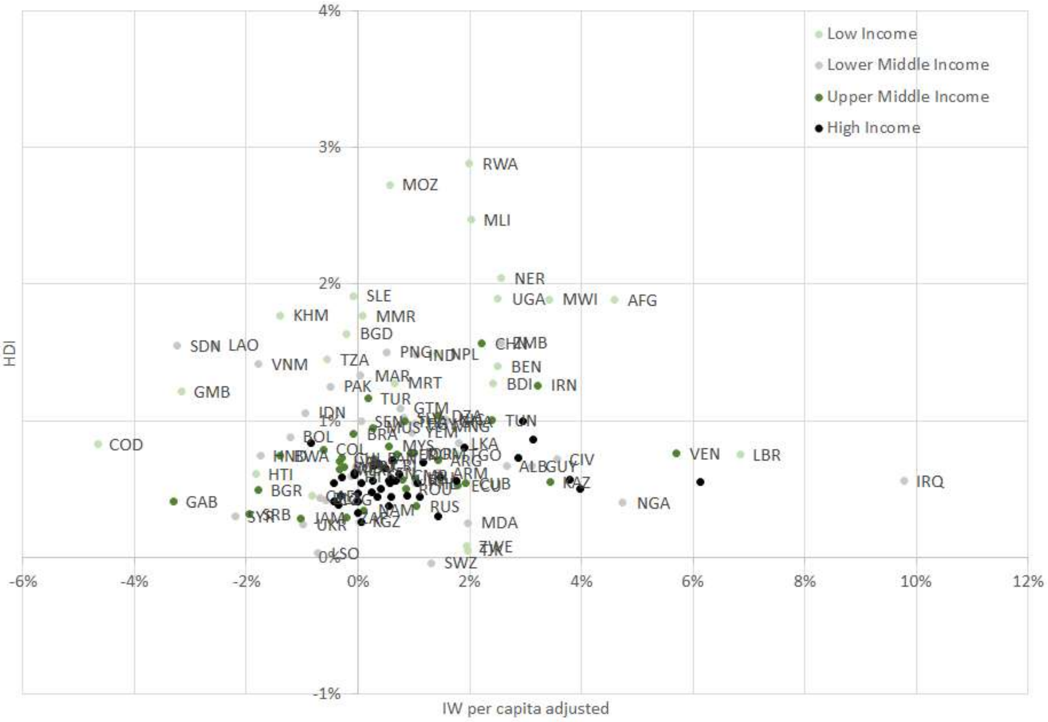


Figure 15a: GDP per capita vs. IW per capita (before adjustment)

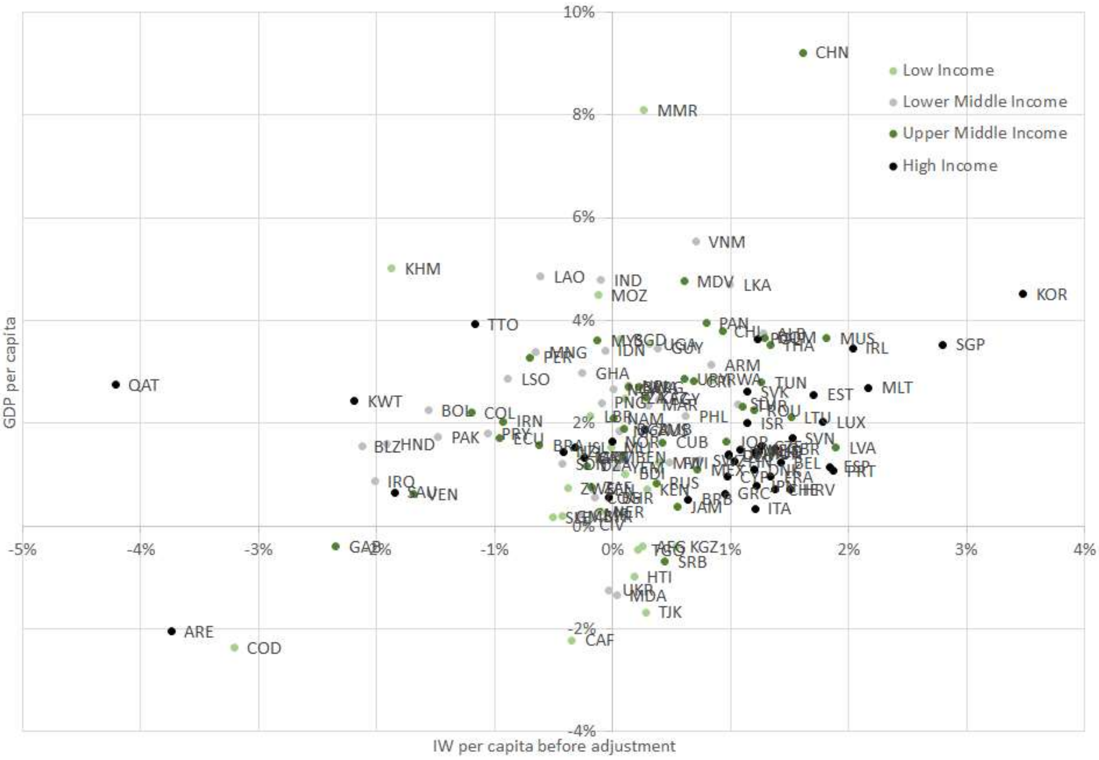


Figure 15b: GDP per capita vs. IW per capita adjusted

Figure 16: GDP per capita vs. HDI

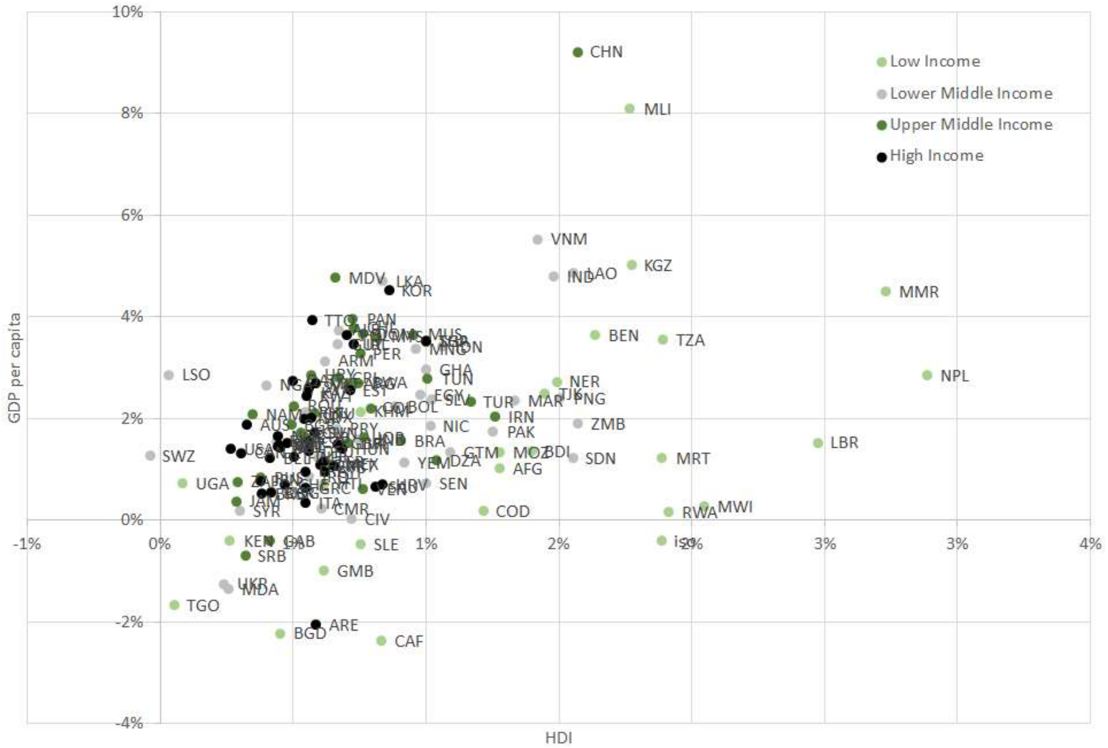


Figure 17a: Happiness vs. IW per capita before adjustment

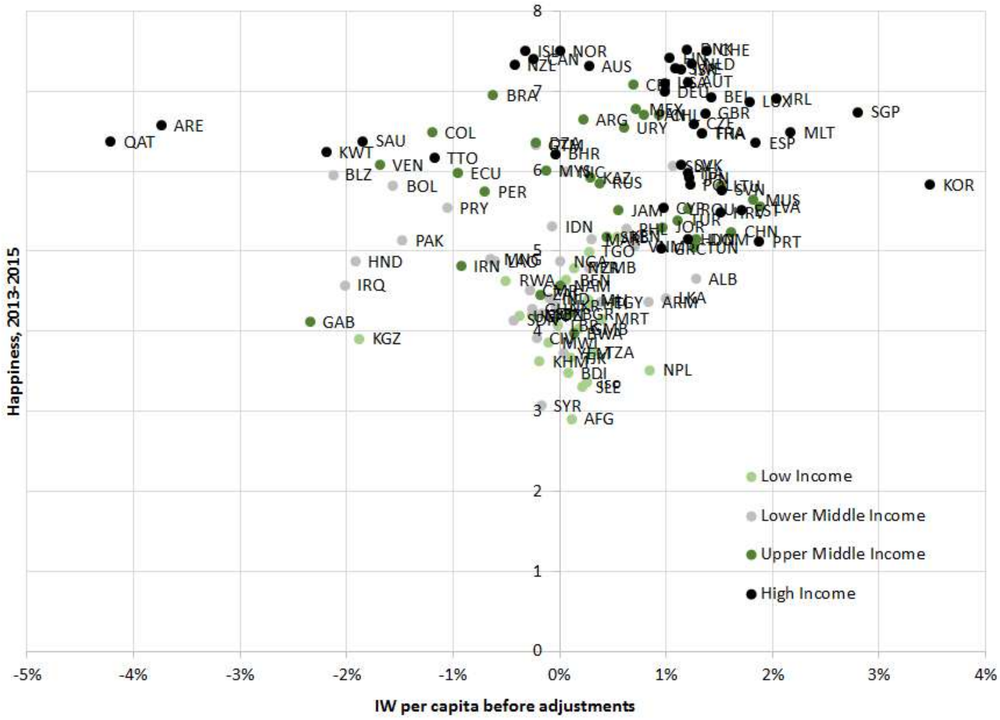
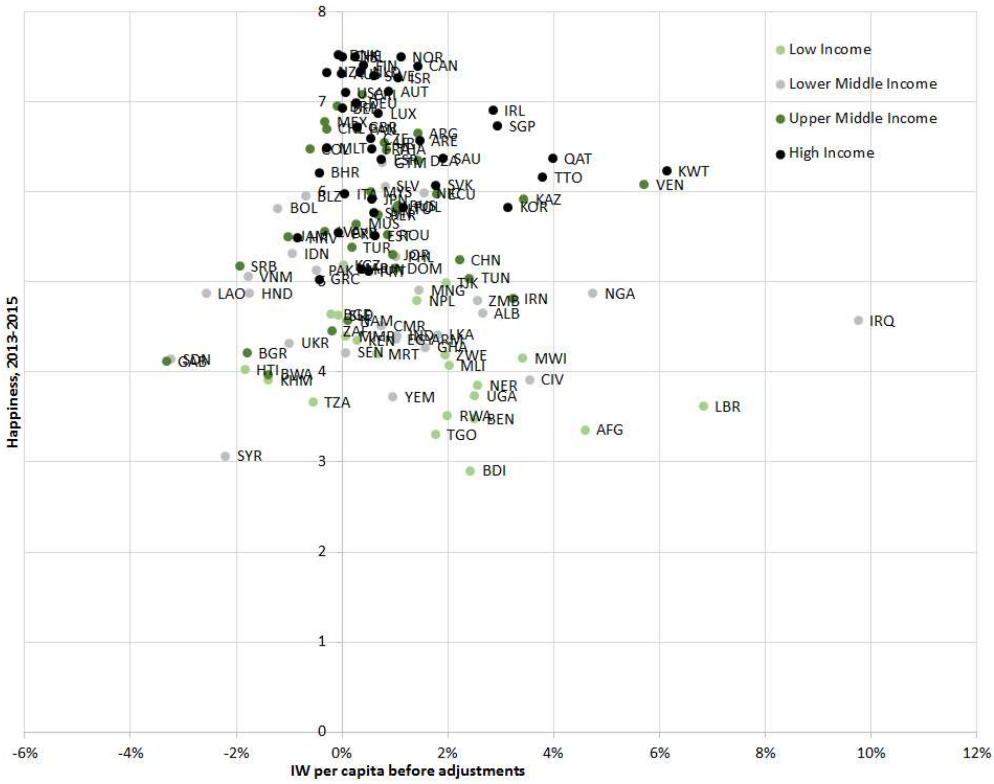


Figure 17b: Happiness vs. IW per capita after adjustment



4. The inclusive wealth of nations: Education as human capital

4.1. Measuring performances based on changes in wealth

This section shows the inclusive wealth of nations following approach used in IWR2012 and 2014. This is based on the idea on education as human capital shadow prices following IWR2012 and 2014, which in the henceforth we call IWR2014 approach. The main difference lies in the calculation of human capital: the educational rate of return is used as its shadow price. In line with IWR2014, health capital is out of the scope in this method, primarily because it would swamp other capital assets. Also, conventional TFP values are used for IW adjusted. We report our results based on this approach, along with the frontier approach in Section 3 as this methodology is in line with the long history of economics of education, and its consistency helps the reader compare our results with previous editions of IWR in a continuous manner. Needless to say, the question to be asked carries on from the previous section: have nations been maintaining their wealth for the past quarter a century? The dataset continues to be the whole 140 countries, from 1990 to 2014.

As the methodology in this subsection inherits that from previous reports (IWR2012 and IWR 2014), it turns out that the basic trend of inclusive wealth also continues to hold from them. In particular, the aggregated accumulation of wealth has been slower than population growth, leading to negative growth rates in inclusive wealth *per capita*.

Figure 18a: Growth in Inclusive Wealth Index (unadjusted), using IWR2014 approach

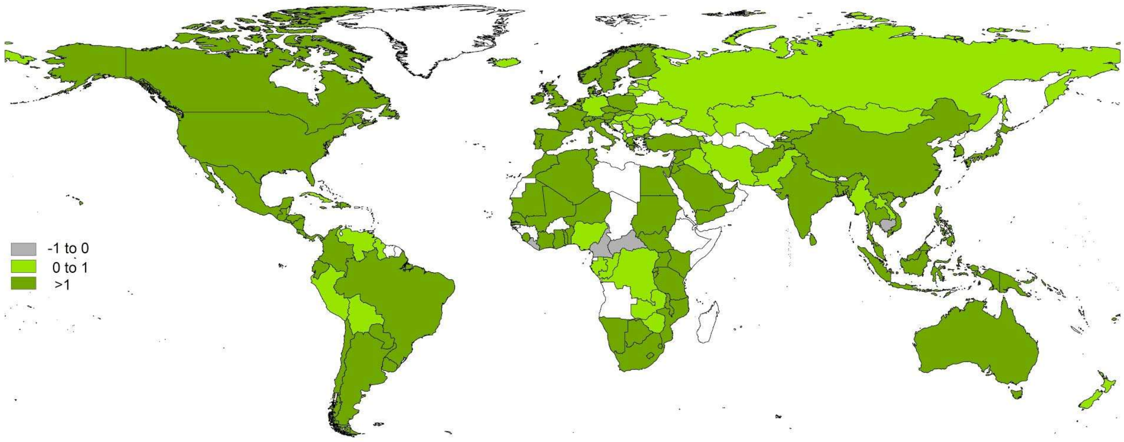


Figure 18 b: Growth in Inclusive Wealth Index per capita (unadjusted), using IWR2014 approach

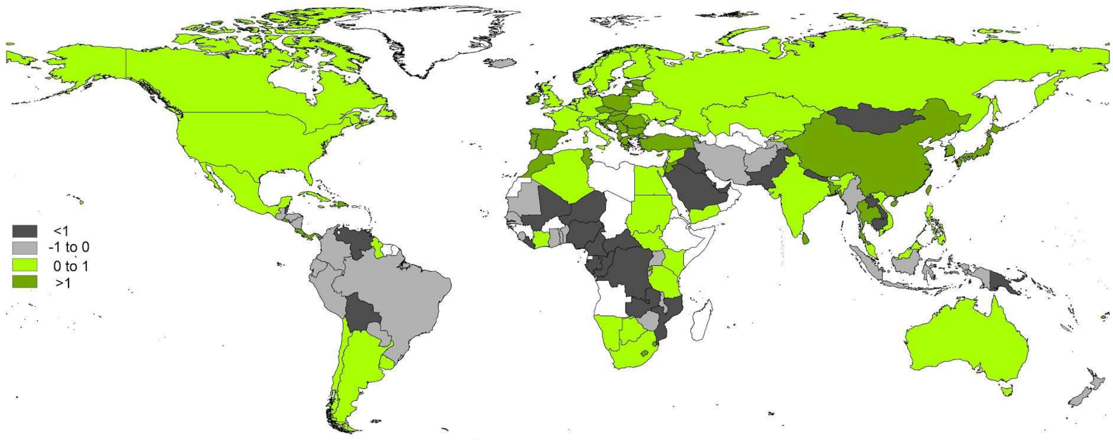
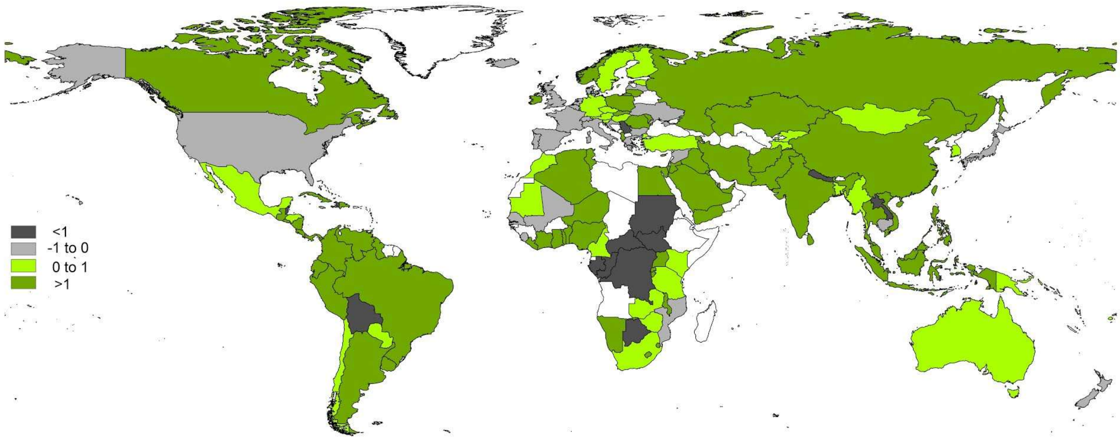


Figure 18 c: Growth in Inclusive Wealth Index per capita adjusted, using IWR2014 approach

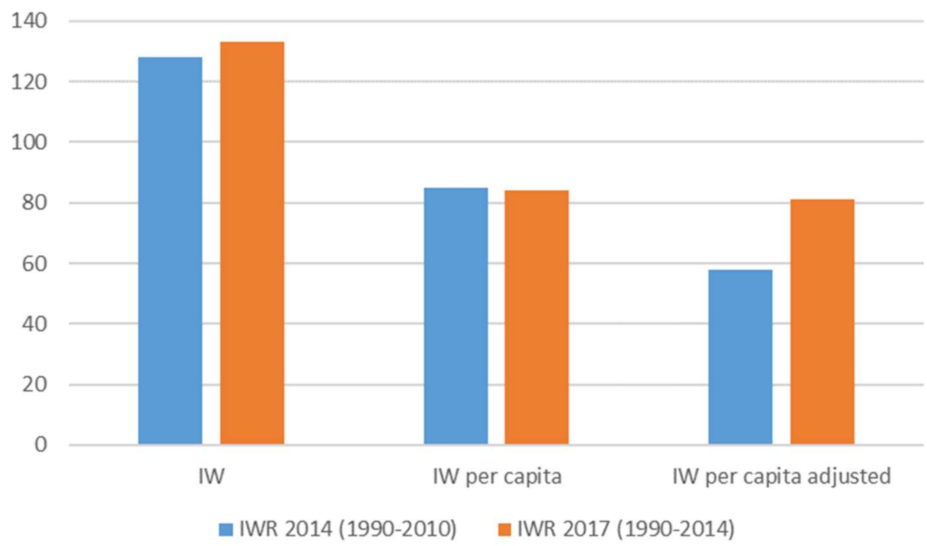


According to the total wealth of nations, 133 out of the 140 countries (95 percent) enjoyed positive growth rates in inclusive wealth over the past quarter a century (see Figure 18 a). That the overall wealth has been increasing in the world in the aggregate seems to be good news, but on the flip side, the remaining 5 countries experienced degradation of their wealth.

If we change the measure from total to *per capita*, 84 out of the 140 countries (60 percent) under study present a positive Inclusive Wealth per capita (see Figure 18 b). The worse performance indicates the simple Malthusian effect on sustainability is negative all over the world, and perhaps more so in developing countries.

Finally, growth in inclusive wealth per capita with adjustments by TFP, carbon damage, and oil capital gains (Figure 18 c) indicates that 81 out of the 140 countries (58 percent) have been on a sustainable path.

Figure 19: Comparison of number of countries of positive IW growth, IWR2014 approach



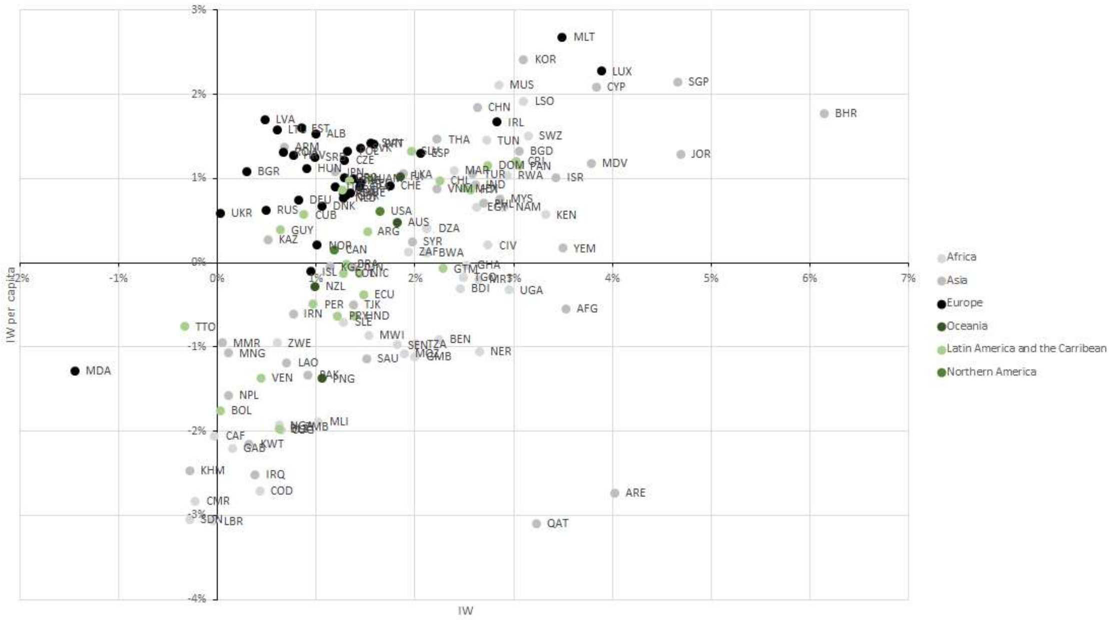
They can be contrasted with previous results of IWR 2014: for the studied period of 1990-2010, only 128, 85, and 58 out of 140 countries (as opposed to 133, 84, and 81 in the current edition) experienced an increase in inclusive wealth in absolute terms, inclusive wealth per capita, and inclusive wealth per capita adjusted, respectively (see Figure 19). Since the sample countries remain unchanged and the methodology has not changed in a drastic manner, this better performance can be traceable either to expansion of the studied period by the recent four years (2011-2014), or to the addition of fishery resources to natural capital.

Figure 20 shows the relationship between inclusive wealth, on an absolute versus per capita basis. Overall, we observe an upward relationship between the two: the larger the growth in inclusive wealth is, the larger the growth in inclusive wealth per capita tends to be. Note also that almost all the European and North American countries fall into Quadrant I: they have experienced increasing wealth in both absolute and *per capita* terms. For the other regions, results are mixed. Bahrain, United Arab

Emirates and Qatar, both sitting on a huge oil and gas capital, lie somewhat as outliers.

The seven countries with negative inclusive wealth growth include four African nations (Cameroon, Central African Republic, Liberia, and Sudan), Trinidad and Tobago, Republic of Moldova, and Cambodia. It is remarkable that, out of the five countries, only the oil-rich Caribbean nation, Trinidad and Tobago, falls into the high-income category. In absolute terms, the country's natural capital has been eroded by 3.9% per annum. It looks like the country has depleted ample natural capital across the board, from agricultural land to oil and gas, but the extent to which nature has been converted into produced and human capital seems to have been insufficient.

Figure 20: Inclusive wealth and inclusive wealth per capita (IWR2014 approach)



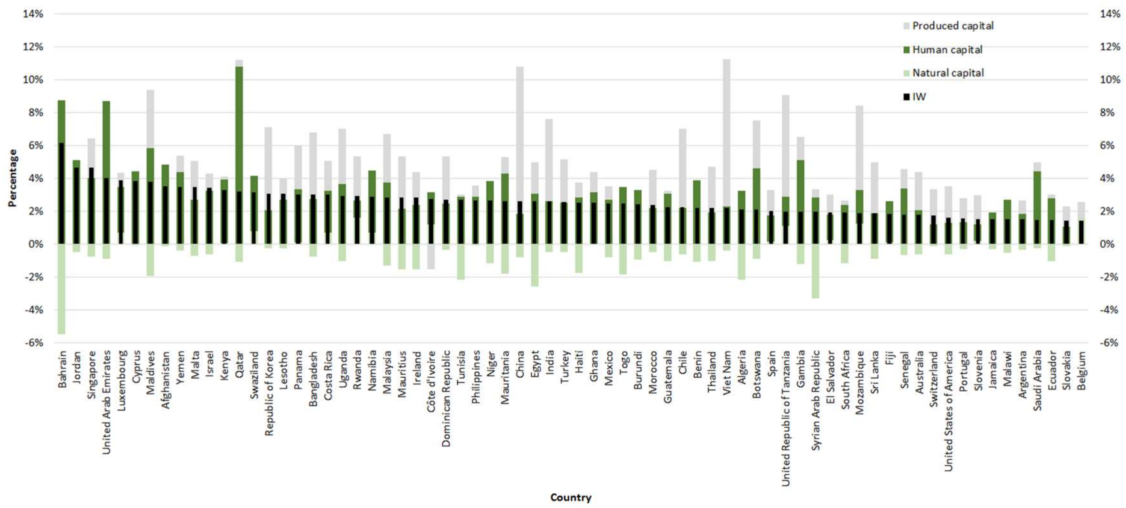
4.2. Wealth change compositions

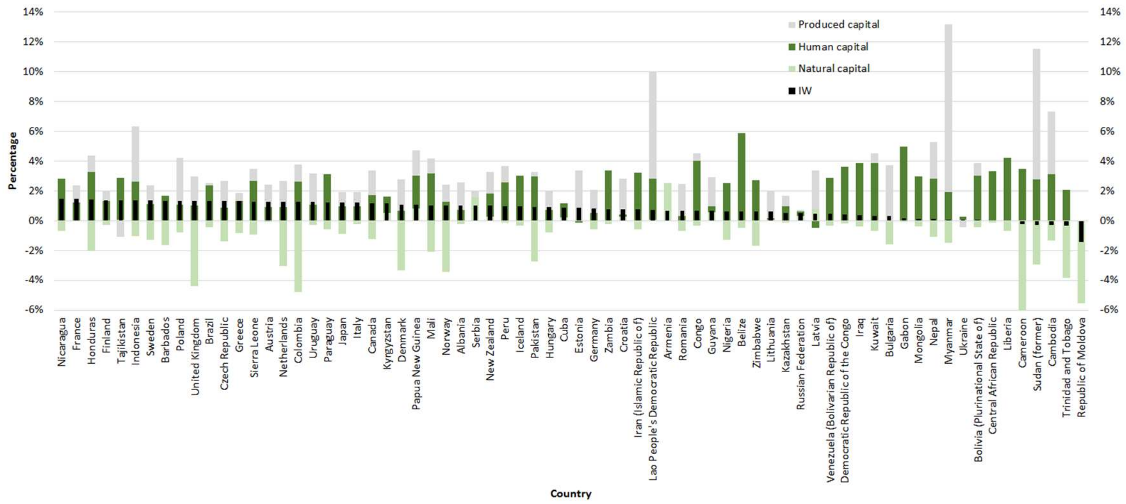
In this subsection, we have a closer look at the breakdown of the contributions of each capital asset group to the total inclusive wealth average growth rates. In particular, Figure 21 shows the breakdown of (unadjusted) inclusive wealth growth into produced, natural, and human capital groups. We can observe that even within high inclusive wealth growth countries, the composition of each capital asset varies. For example, oil-rich gulf nations (Bahrain, United Arab Emirates and Qatar) have converted massive natural capital into other capitals, especially human capital. Other nations, such as Singapore, Tanzania, Bangladesh, South Korea, and Philippines, among others, have been on a sustainable path, primarily by growing their produced capital, with very little rundown of their natural resources, or because they are poorly endowed with them in the first place.

Turning to unsustainable or barely sustainable countries in Figure 21, despite their sluggish growth in inclusive wealth, it should be noted that human capital has grown more than 2%, with several exceptions. Therefore, degradation of natural capital and slow growth in produced capital are mainly responsible for their disappointing growth rates of inclusive wealth. Notable exceptions include several former Soviet-Union countries such as Ukraine, Russia, Kazakhstan, Lithuania, and Republic of Moldova, whose populations, and thus human capital, have decreased in the latest quarter a century. Furthermore, all of these countries have declined their natural capital; whereas Republic of Moldova was the only country which eroded all the three capital assets.

We note here that, since the growth rates are expressed in geometric mean, the growth rates of each component do not simply add up. Therefore, some ASEAN countries like Laos, Myanmar, and Cambodia has recently accumulated produced capital, which do not contribute to high growth rates in inclusive wealth for the studied period.

Figure 21: Breakdown of growth rates of inclusive wealth into three capital assets, before adjustments (IWR2014 approach)

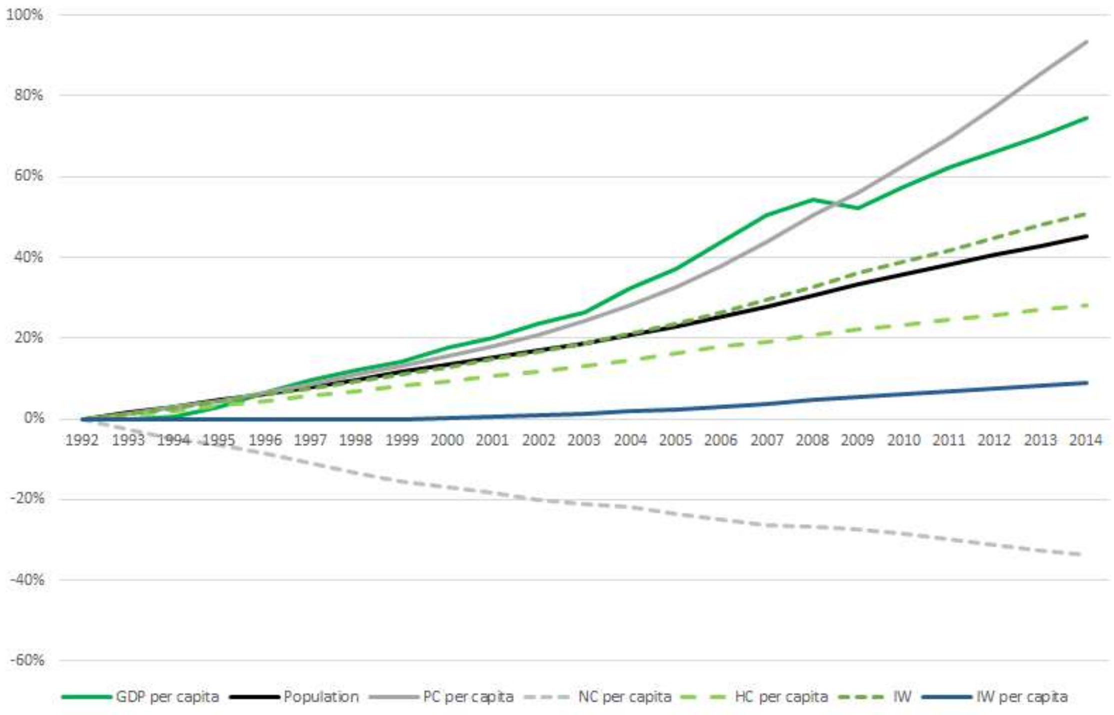




What if we aggregate all the countries all over the world? In other words, has the world been preserving its wealth on the whole? Figure 22 shows the global change rates of inclusive wealth and its components on a *per-capita* basis, setting 1992 as the reference year[6]. Inclusive wealth per capita has been slightly positive, especially so in the last decade. Observe that this is a cumulatively large drop from inclusive wealth in absolute terms. Figure 22 also demonstrates vividly that natural capital degradation – which amounts to some 35% in a cumulative fashion – has been compensated by investment into human capital, and, to a much larger extent, into produced capital.

Another interesting observation from Figure 22 is that, all the capital assets growth has been linear, if we aggregate across the world, whether they have been positive (produced and human) or negative (natural). In contrast, GDP growth has been mostly linearly positive, but a huge financial crisis has made a dent in the path in 2008.

Figure 22: Growth rates of inclusive wealth *per capita* and its components, relative to the level of 1992, world (IWR2014 approach)



4.3. Wealth compositions

As we have reiterated, what matters in sustainability assessment is the change in capital assets over the course of the years. However, it is of some interest to also have a look at the composition of capital

[6] The years 1990 and 1991 are skipped here, to avoid missing data in some former USSR countries.

assets themselves. Figure 23 shows the percentage of three capitals in inclusive wealth, averaged for the period between 1990 and 2014. Panel a of the figure in the following suggests that it accounts for less than 20% of total wealth in many countries. It is relatively more important in some developed nations such as USA, Europe, South Korea and Japan. In contrast, the share of produced capital is alarmingly low in some developing countries; it accounts for less than 5% in some sub-Saharan African countries in 2014. It is hard to draw normative implications just from this percentage, but investing in produced capital would help some poor countries take off, as history suggests.

Figure 23b shows (education-induced) human capital share, annually averaged for 1990-2014 for the whole world. It demonstrates that human capital accounts for the lion's share in many countries. There are, however, several exceptions in the less developed world. As of 2014, it is still less than 20% in Belize, Bolivia, Guyana, Central African Republic, Laos, Liberia, Mongolia, Papua New Guinea, and Tanzania.

Finally, Figure 23c represents the natural capital share in inclusive wealth. In contrast to other capital forms, the share of natural capital largely depends on initial endowments, so it is not infrequently very small, whether in low-income or high-income countries. For example, natural capital stands for less than 5% both in Belgium and Bangladesh. It is also worthwhile mentioning that some countries that are presumably rich in natural capital are actually running out of them: less than 1% of wealth is in the form of natural capital in Bahrain and United Kingdom as of 2014. Both of them may have depleted their oil capital in the last several decades.

Figure 23: Percentage of produced, human, and natural capital in total wealth, average for 1990-2014, IWR2014 approach

Figure 23 a: Percentage of produced capital in total wealth

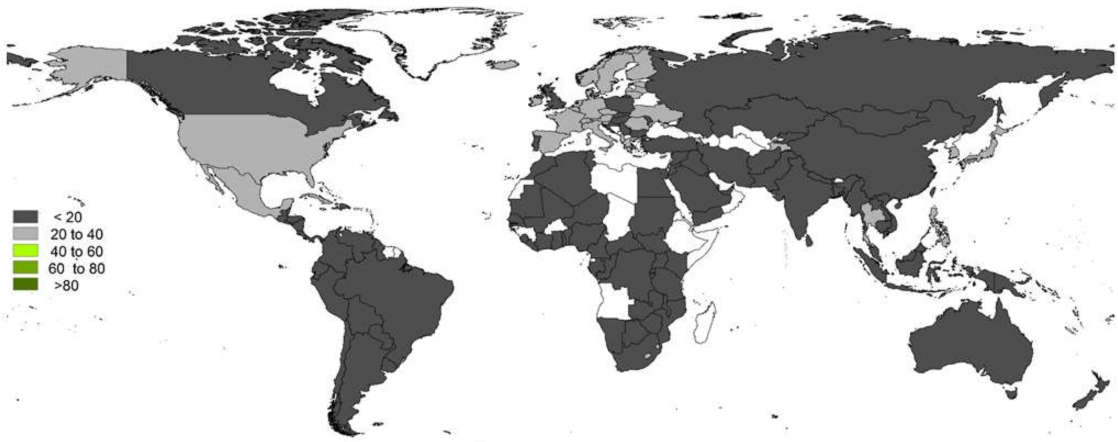


Figure 23 b: Percentage of human capital in total wealth

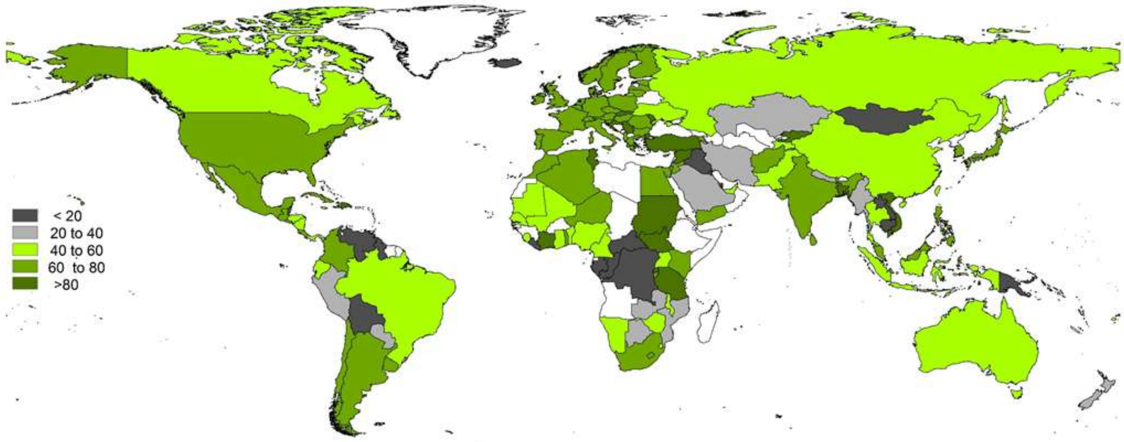
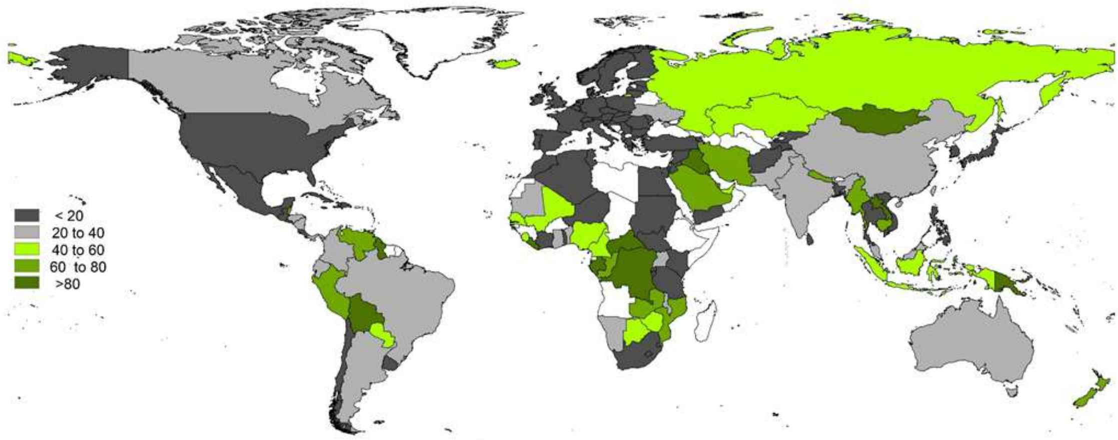


Figure 23 c: Percentage of natural capital in total wealth



What about the wealth composition across the whole world? Figure 24 a says that, on the average, human capital is responsible for more than half of inclusive wealth. This is followed by natural capital, with around a quarter of total wealth. Produced capital accounts for the smallest share of inclusive wealth, less than one fifth of total wealth around the world. These figures Note, however, that this figure is aggregated both across time and the globe. In order to see the temporal change of this composition, the right panel of Figure 24 a shows their temporal development. One can see clearly that natural capital has been substituted primarily by produced capital. It is somewhat surprising to see that the shares of natural and produced capital converge to approximately 20%. Meanwhile, the share of human capital continues to account for more than half of total wealth.

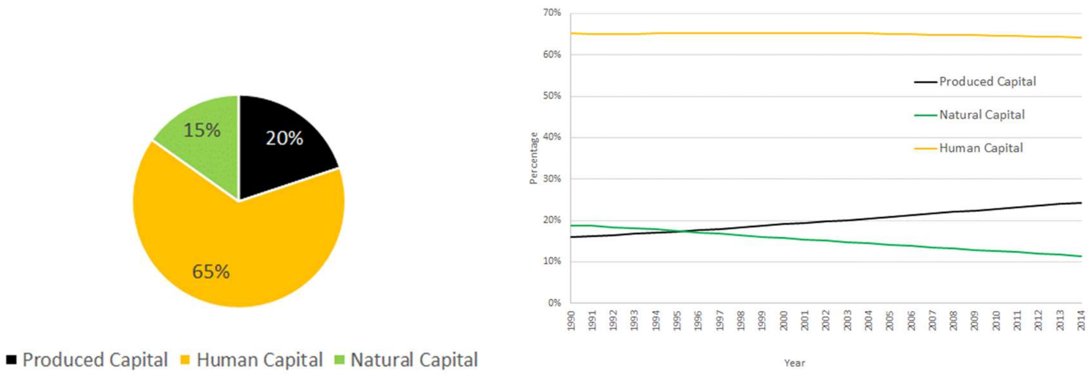
However, a different picture emerges when we aggregate in a different manner. In Figure 24b, instead of taking the average of the shares, we first aggregate each capital for a specific year for the whole world, to compute each capital share in the right panel. This is further averaged for the whole period in the pie chart. According to this calculation, the place of produced and natural capital was being changed in the mid-1990s. Furthermore, natural capital only accounts for 15% of total wealth, which is somewhat a sobering figure in light of the time trend.

This replacement of natural capital by produced capital should be examined in further detail. Inclusive Wealth Report 2014 found that the share of produced capital tends to be around a little less than 20% in many countries, and – interestingly – that natural and human capital shares tend to be inversely correlated. This tendency continues to hold for our updated data, as shown in Figure 24c. This apparently linear relationship between produced and natural capital tempts us to assert that natural capital is being depleted and converted into human capital. Our approximation suggests that, if one starts from the state of natural capital being 100% of wealth, a 20% decrease in natural capital would translate into 15% increase in human capital. This would be reminiscent of the well-known Hartwick rule, which says that rents of depleted natural capital should be invested into other forms of capital in order to maintain future consumption and well-being (Hartwick 1977; Dixit et al. 1980). Although this story is easy to comprehend, recall that the apparent relationship in Figure 24c only represents that of cross-country. In other words, the way capital assets are substituted with each other differs from country to country along their historical paths. Moreover, it is important to remind that this correlation does not suggest any causation; it could be that, in theory, nations can invest into natural capital, resulting in a lower share of human capital.

Figure 24a: Global aggregate wealth composition, mean 1990-2014 and across time, IWR2014 approach

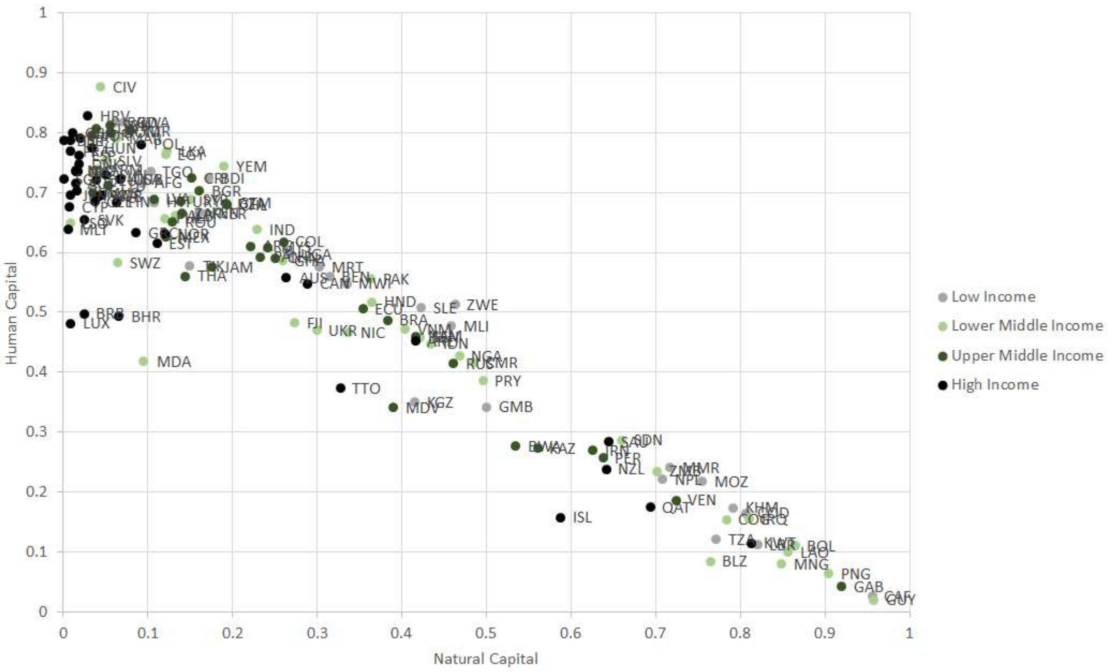
Note: Shares of each capital are computed for a specific country and year first, which are aggregated across countries in the right panel. This is further averaged for the whole period, 1990-2014, in the left panel.

Figure 24b: Global aggregate wealth composition, mean 1990-2014 and across time, IWR2014 approach



Note: Each capital is first aggregated across the countries for specific years in the right panel. This is further averaged for the whole period, 1990-2014, in the left panel.

Figure 24c: Percentage shares of human capital and natural capital in total wealth, average 1990-2014 (IWR2014 approach)



To sum up, it is confirmed that natural capital has been used to increase produced, and to a lesser extent, human capital. The higher the share of natural capital share, the lower the share of human capital tends to be. However, this is the global aggregate, and a closer look is always warranted. In particular, the share of natural capital has got little to do with the advancement of the economy in question. After all, it is the change in the combined wealth that counts.

4.4. IWI adjusted

As we have demonstrated in methodological section, the increase in inclusive wealth should show the same direction in which social well-being is moving. Aside from population growth and its Malthusian effect, there are at least three factors that affect social well-being but get around the three capital channels: carbon damage, oil capital gains, and TFP. Carbon damage erodes a nation's well-being because of its nature as a global public bad; the damage to the economy caused by climate change, which is affected by an aggregate of global carbon emission, does not necessarily have something to do with its own level of carbon emission or natural capital change. Oil capital gain is the boost of total wealth by an exogenous increase in the price of the natural capital. The economy can also enjoy improved social well-being in the presence of the increase in TFP, even without any improvement in the quantity of inclusive wealth. This represents a technological progress in a wide sense across the whole society. Of course, one can think of TFP as another capital asset (Arrow et al. 2012).

Figure 25 shows the breakdown of the change in inclusive wealth, adjusted for the three terms. The Figure starts from IW *per capita*, and then introduces carbon damage, oil capital gains/losses, and TFP, to reach IW *per capita* adjusted.

Not surprisingly, carbon damage as a share of inclusive wealth takes its toll more for small countries, as their inclusive wealth tends not to be large enough to absorb such exogenous shocks. In this regard, our measure proves useful as we express carbon damage as the share of inclusive wealth. Per annum, the carbon damage adjustment does not exceed 1% of their inclusive wealth, and it proves to be the least contributor to the adjustment terms of inclusive wealth. The largest order of carbon damage with regard to inclusive wealth is seen in Luxembourg (-0.6%), followed by Malta (-0.4%), Maldives (-0.4%), Bahrain (-0.4%), Barbados (-0.3%). It should be noted that it is the well-known island nations that are most vulnerable to climate change and on the verge of non-existence, some of which are out of the scope of our 140 studied countries. In absolute terms, however, carbon damage is relatively large in high-income countries such as Germany, France, United Kingdom, United States, among others. In per capita terms, carbon damage exceeds USD500 in Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, United Kingdom, Ireland, Iceland, Italy, Luxembourg, Netherlands, Norway, and Sweden. It is also interesting to note that some countries get *better* off by climate change: Australia, Canada, Israel, New Zealand, Russia, and Singapore actually gained as a result of global carbon emission. Thus, in those countries carbon damage is recorded in positive terms in our accounting.

A much larger effect can be observed for oil capital gains and losses. In the current edition, an annual increase of 3% in the rental price of oil is assumed, which corresponds to the annual average oil price increase during 1990-2014 (BP 2015). This means that, even if oil is not withdrawn at all, the country in question can enjoy 3% growth in social well-being[7][8]. As shown in Figure 26, there has been a dramatic volatility in the oil price in the last decade. Over the last quarter a century, however, oil capital gain reads more than 1% annually of their inclusive wealth in the following dozen countries: Kuwait (7.7%), Iraq (7.0%), Venezuela (6.1%), Qatar (5.9%), United Arab Emirates (5.4%), Saudi Arabia (4.5%), Iran (3.1%), Nigeria (3.0%), Uganda (2.1%), Kazakhstan (1.8%), Ecuador (1.4%), and Canada (1.1%). They are all countries whose reserves of either oil or natural gas are huge, regardless of their income levels. As unconventional fossil fuel such as shale oil and gas comes to the fore, countries endowed with them would gain more if oil prices continue to increase. Among those nations with large oil capital gains, the IW per capita adjusted of United Arab Emirates ends up with a moderate 2.0%. In other words, had they extracted their oil wealth more moderately, their IW per capita would have been on a par with, say, United Kingdom.

On the flip side, as sources of wealth cannot appear out of the air, there are "losers" in terms of this exogenous oil price movements. For completeness, we record negative numbers to those which have faced higher import price of oil. Those importing countries with negative oil capital gains comprise the majority (113 out of 140 countries). The biggest oil capital loss appears in Singapore, being equivalent to -1.5% per annum of its initial wealth in 1990. This is followed by smaller nations such as Malta (-1.1%), Jordan (-1.0%), Maldives (-0.9%), and Panama (-0.8%), as their inclusive wealth is considered to be relatively scarce with regard to importing oil price shocks. In comparison with oil capital gains, the order of magnitude of capital loss for individual countries is smaller, reflecting the fact that oil-importing countries are geographically much more dispersed than exporting ones.

Figure 25: Breakdown of growth rates of inclusive wealth adjusted into three adjustment assets (IWR2014 approach)

[7] In theory, the value of oil natural capital can stay intact, if the decreasing rate of oil quantity can be compensated by the oil price increase rate when the quantity being fixed.

[8] When oil price is expected to increase in the future for some reason or another, the current list of capital assets could also be adjusted to reflect such a gain in social well-being (Vincent et al. 1997; Hamilton and Bolt 2004; van der Ploeg 2010). We do not consider this possibility, since future oil price is too uncertain, as our recent experience demonstrates.

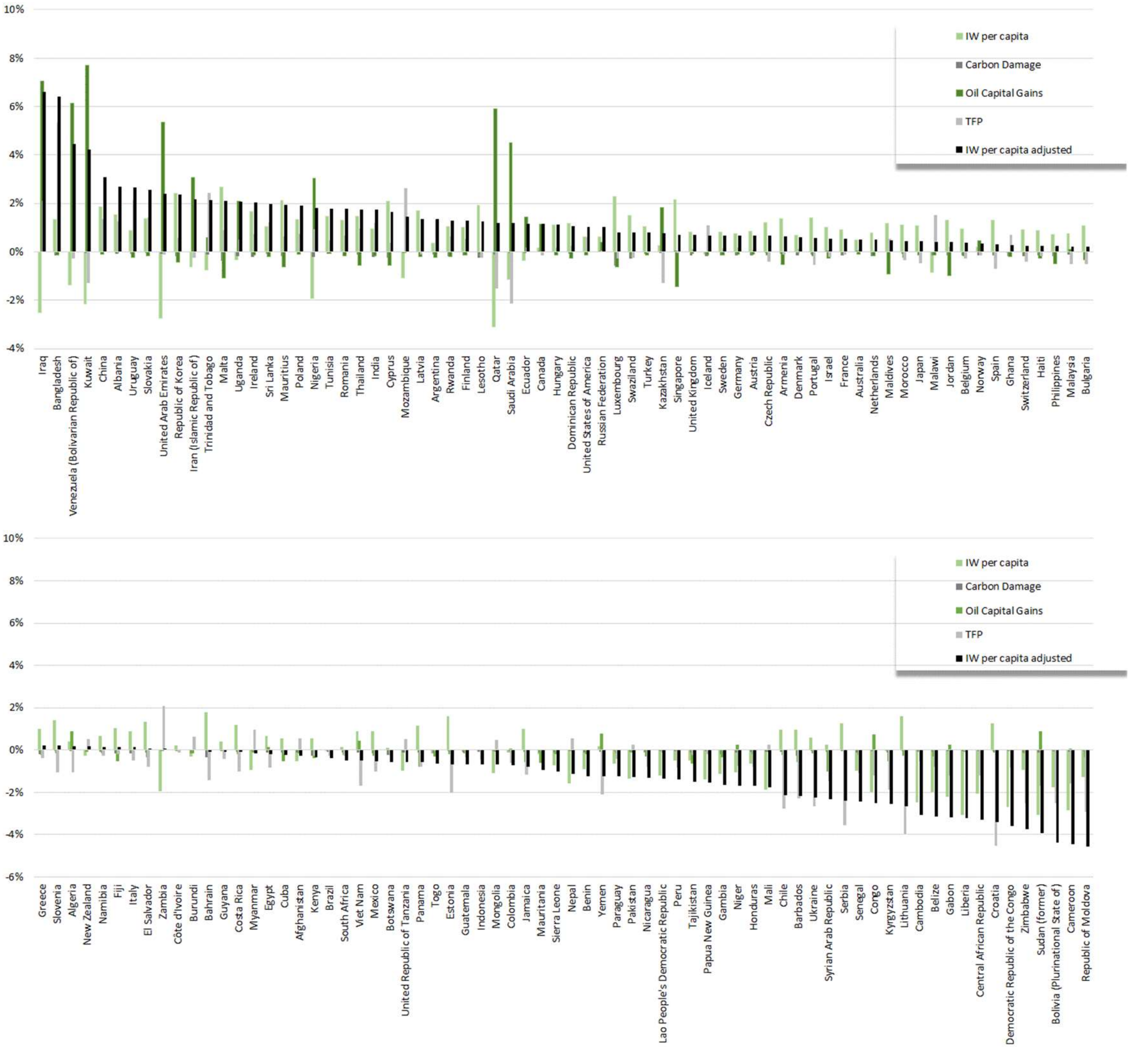
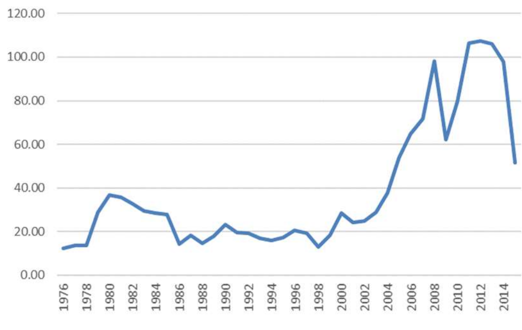


Figure 26: Crude oil price movements since 1976, USD, with no inflation adjustments



Source: BP (2015), averaged prices of Dubai, Brent, Nigerian Forcados, and West Texas Intermediate.

Finally, TFP measures the residual of GDP growth for which contributions of three capital assets cannot explain. As Arrow et al. (2012) demonstrated, all we have to do is add the residual TFP growth to the change in inclusive wealth growth. In the IWR2014 approach of this section, we take a different tack from the frontier approach in Section 3, and instead follow IWR 2012, taking the 25-year average of the TFP growth rates reported by Conference Board (2017)[9]. The only shortcoming of this dataset is the lack of natural capital as an input, which implies that the TFP values might overestimate the true technical progress. However, this is not a serious concern because, in our purpose of sustainability assessment, the final IW per capita adjusted by TFP would be the lowest bar to overcome. The development paths of those countries with negative IW per capita, with somewhat optimistic TFP, would not be judged as sustainable even if TFP considering natural capital input were readily available. The top countries in terms of annual average TFP growth rates include Bangladesh, Mozambique, Trinidad and Tobago, Uruguay, and Iraq, all surpassing 2%. Less than half of the sample (52 out of 140) has witnessed a positive growth in TFP over the last 25 years.

All things considered, the ultimate IW growth rate, which is adjusted for the three factors along with population growth, can be calculated and shown as in Figure 25. Among the top countries, Iraq, Venezuela, Kuwait, and United Arab Emirates all have experienced negative inclusive wealth per capita, because of the depletion of their oil capital. It demonstrates how much oil capital gains may have worked as proverbial windfall benefits in terms of sustainable development of those nations. Bangladesh, China, Albania, Uruguay, Slovakia, and South Korea have moderately accumulated inclusive wealth and TFP.

On the opposite end, 59 countries have seen negative growth in IW per capita adjusted. It is remarkable that, aside from Croatia, all the worst 10 countries have had both negative inclusive wealth per capita and negative TFP. If they not only continue to lack investment in the usual set of capital assets but also are sluggish in improving the overall efficiency of economies, their paths to sustainable well-being look far-fetched.

4.5. Comparison with GDP and HDI

In this subsection, we compare our results based on conventional calculation with the past performances of other well-known indices. GDP per capita is the most popular index to date for monitoring progress of nations. Since its launch in early 1990s, Human Development Index (HDI) is also widely cited as an index for tracking development of nations. HDI is a composite index of human capital (health and education) and income levels (GDP). Happiness, or more generally, subjective well-being gathers attention recently. This sheds light on the other side of social well-being than our determinant-based indicator of social well-being. Finally, the closest to our index is the World Bank's genuine savings, formally adjusted net savings, which keeps track of savings (and dissavings) in produced, human, and natural capital. For our comparison, we exhibit IWI per capita, both before and after adjustments, because they turn out to differ widely.

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[9] Out of the 140 country sample, there are 33 countries whose TFP data are missing in Conference Board (2017), which are complemented by regional average.

4.5.1. GDP per capita

GDP has been criticized for sending a wrong message regarding sustainability of social well-being. Their growth can differ from our IWI per capita, as shown in Figure 27 a and b. Countries in Quadrant I, which is the majority, have experienced both positive GDP and IWI on per capita terms. This is understandable to a certain extent, since portions of GDP are directed toward investment into capital assets. More importantly, several dozens of countries still fall into Quadrant II, with positive GDP per capita but negative IW per capita, both in non-adjusted and adjusted terms. Note, from Quadrant IV, that the reverse is not true: positive IW per capita means negative GDP per capita only for five countries and two countries, without and with adjustments, respectively. This goes to show that it might be sufficient to monitor IW per capita growth, even for the purpose of tracking GDP growth.

There is very little correlation between GDP per capita and IW per capita before adjustment, but there is a weak but positive correlation between GDP per capita and IW per capita adjusted for all the income strata. The latter is not surprising, since one of the adjustment terms, TFP, measure the unaccounted-for contribution of capital assets to GDP.

Figure 27 a: Growth rates in IW per capita (IWR2014 approach) vs. GDP per capita

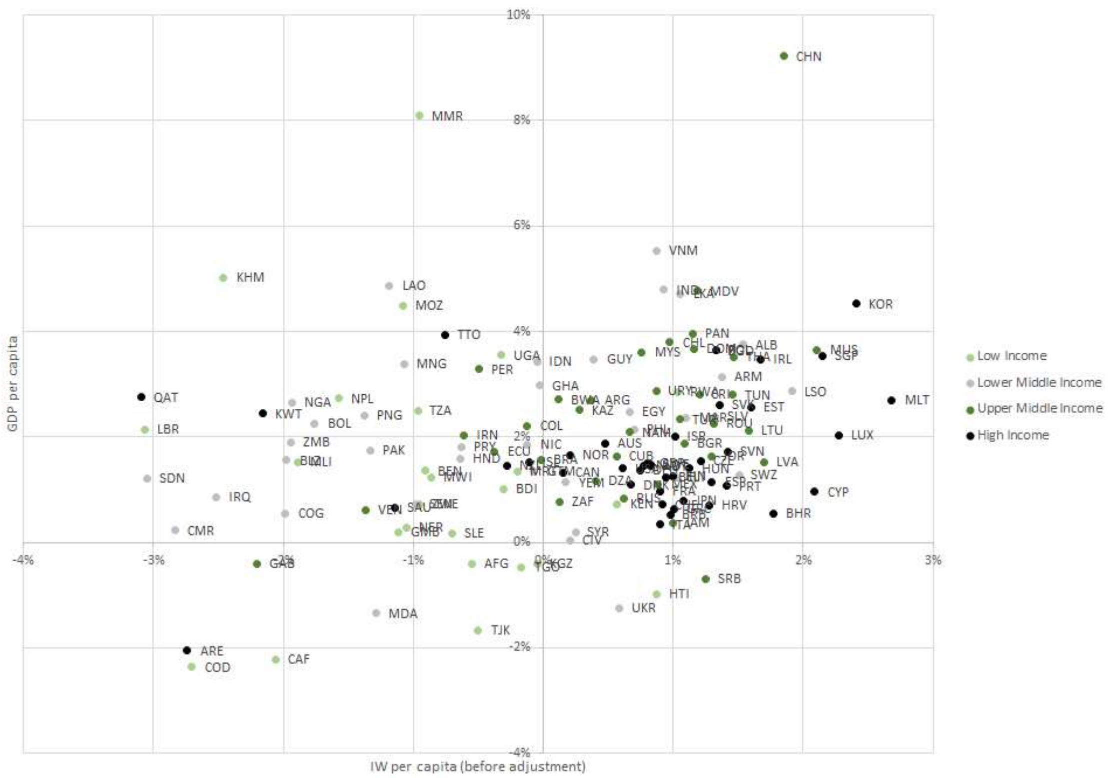
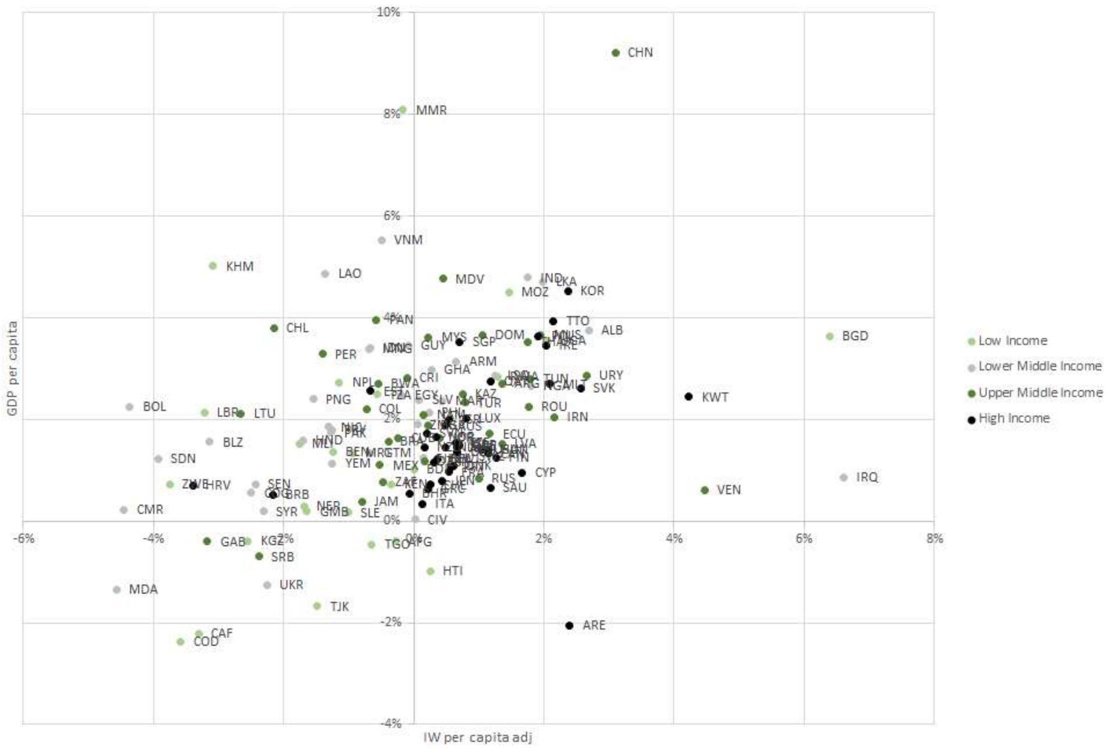


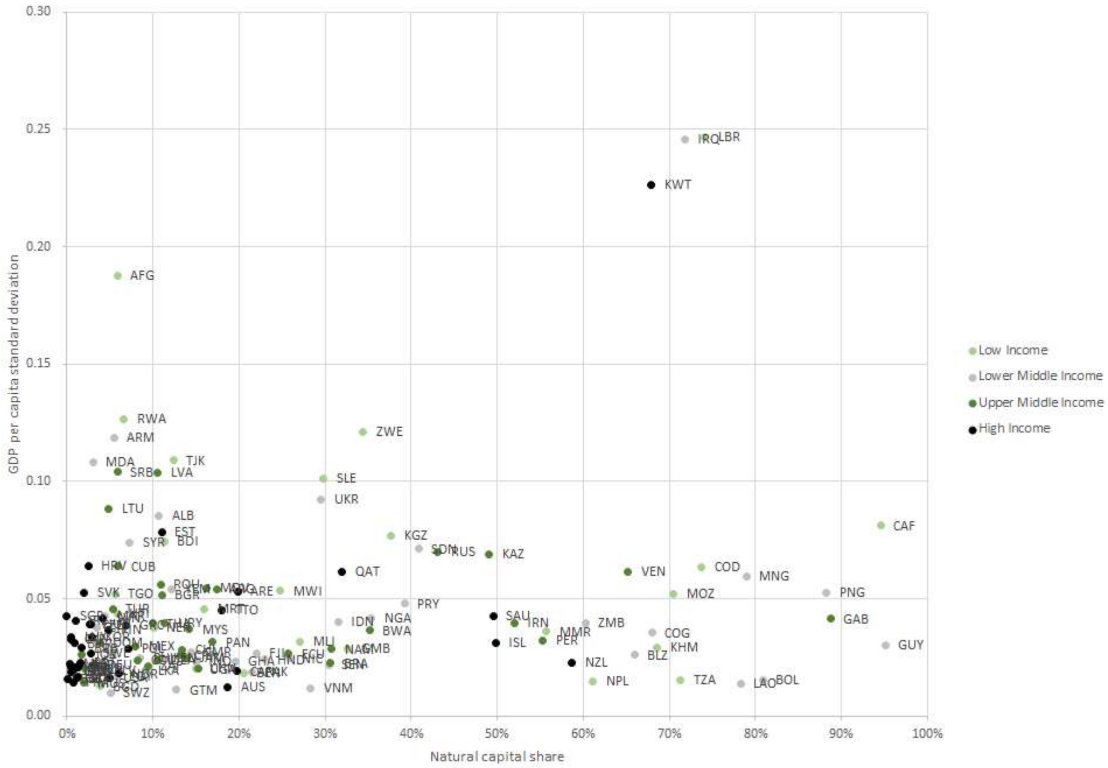
Figure 27 b: Growth rates in IW per capita adjusted (conventional approach) vs. GDP per capita



4.5.2. Growth volatility

Some authors argue that volatility of resource prices could hurt economic performance (e.g., van der Ploeg and Poelhekke 2009). Although there is no formal theory to prove that volatility of output hampers sustainable development, it would be helpful to have a picture of how these two can be placed in our language. Figure 28 plots GDP volatility as measured by standard deviation of the past 25-year output and the natural capital share. Contrary to our predictions, there is almost no relationship between volatility and dependence on natural capital. Although not reported, we do not see a clear correlation between volatility and IW per capita growth rate, either. Those countries which depend highly on natural capital are not necessarily experiencing volatile output growth, although Iraq, Kuwait, and Liberia have seen bumpy growth rates.

Figure 28: Natural capital share in 2014 (IWR2014 approach) vs 25-year average GDP per capita variation (standard deviation)



4.5.3. Human Development Index (HDI)

What about the correlation of IWI and another oft-cited index of development, HDI? Figure 29 a shows that there is no apparent relationship between the two indices. For lower middle income countries, it even shows a slightly negative relationship; thus HDI could send a misguided message regarding sustainability. However, with a closer look at Figure 29 b, we could say that the higher the growth IWI per capita adjusted, the higher HDI growth, for a limited set of nations, with a slightly weak correlation of R^2=0.17 for low income nations and R^2= 0.21 for upper middle income countries. No such relationship is clearly detected for high or lower middle income nations. Again, a slightly better fit for IW per capita adjusted can be justified, since the economic component of HDI is GDP per capita, which contains TFP that is used in our adjustment terms to IWI.

Figure 29 a: Growth rates in IW per capita (IWR2014 approach) vs. HDI

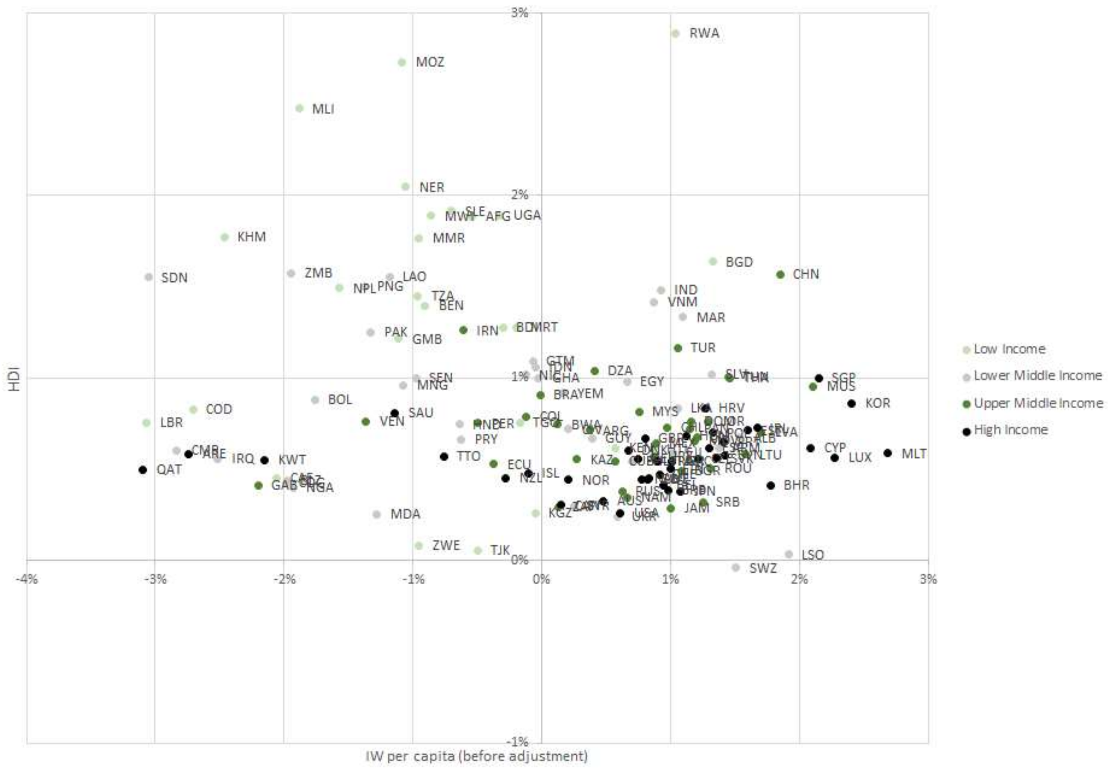
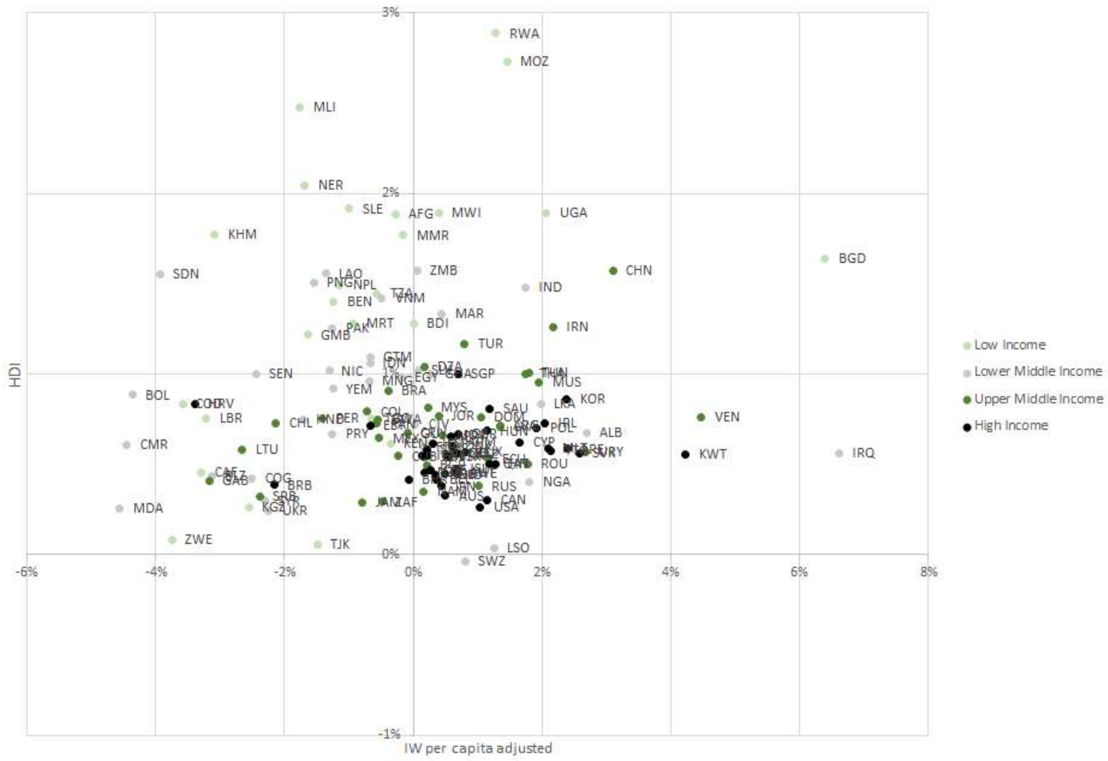


Figure 29 b: Growth rates in IW per capita adjusted (IWR2014 approach) vs. HDI



4.5.4. Happiness

As we articulated earlier in this chapter, inclusive wealth addresses the determinants of social well-being. Capital assets comprise productive base of the economy, which in turn become source of utility for further generations. It is not meant, therefore, to address constituents of well-being (Dasgupta 2001). It is not that constituents can be ignored; on the contrary, they can complement each other to express current and future social well-being.

As depicted in Figure 30 a, there seems to be almost no correlation between the twin aspects of well-being, at least for our studied sample. Note that the vertical axis represents the status of happiness, instead of the growth rate of happiness. For some income categories, even a slightly negative relationship can be detected. Although we are tempted to cynically state that non-declining inclusive wealth may not be able to buy happiness, this observation is not necessarily bad news; as we have argued, they are totally different aspects of social well-being, highlighting the need to let them complement each other.

Figure 30 a: Growth rates in IW per capita (IWR2014 approach) vs. Happiness

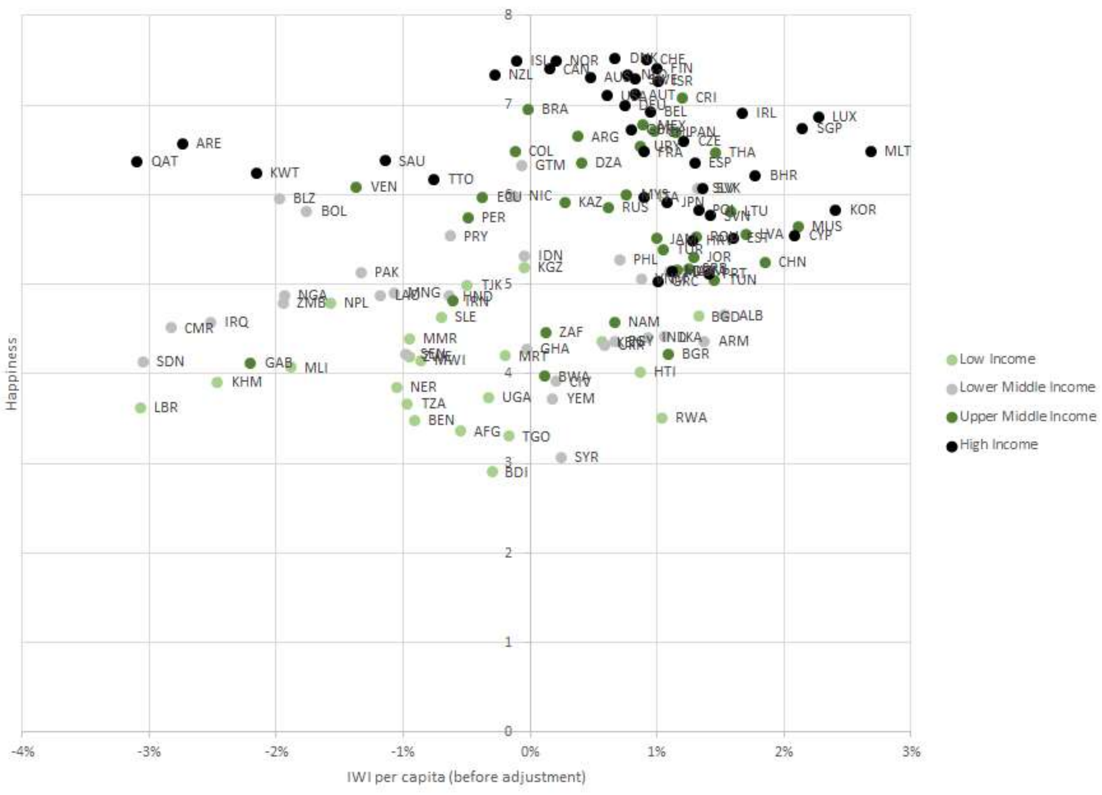
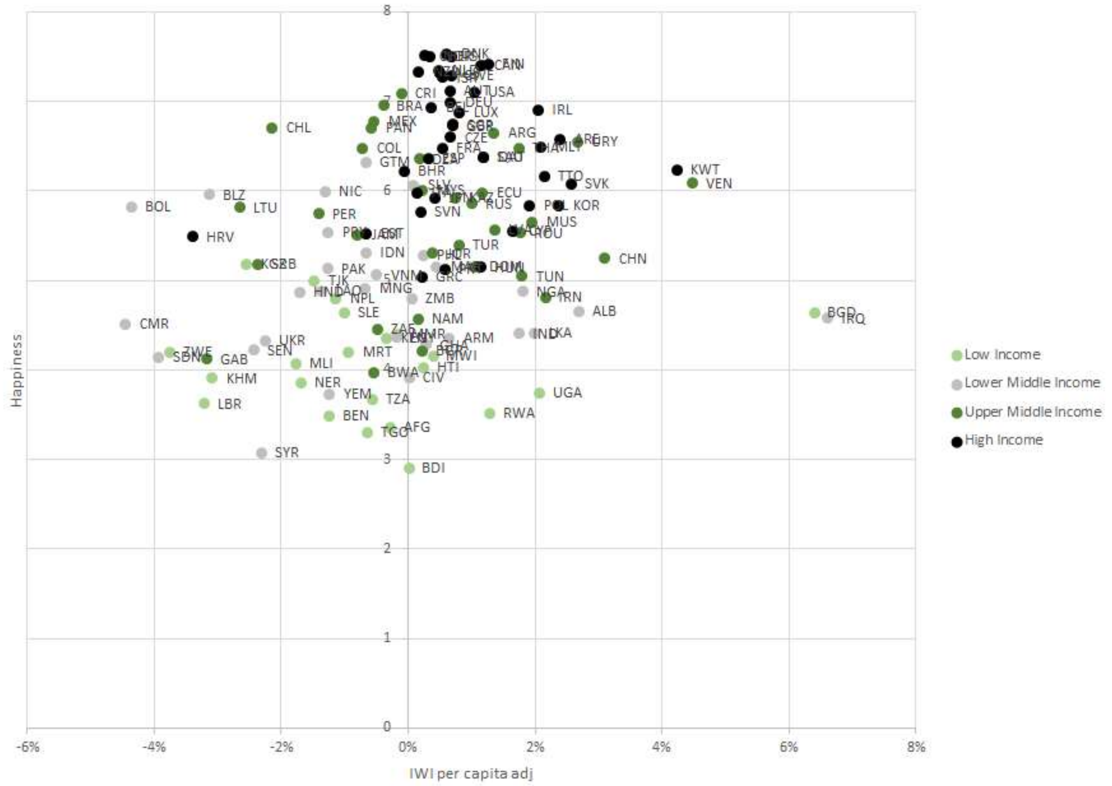


Figure 30 b: Growth rates in IW per capita adjusted (IWR2014 approach) vs. Happiness



4.5.5. Genuine savings

As part of their World Development Indicators database, World Bank started computation of genuine savings of nations as early as 1999. Their composite index is affine to our IWI, as they both measure the change in produced, human, and natural capital. However, we differ from them in many important details. Most notably, World Bank does not compute capital assets *per se* annually; what they account for is the change in capital assets. For example, the change in produced capital corresponds to net national savings. Human capital is recorded as the change in inputs (i.e., education expenditure) instead of outputs (i.e., return on education). For natural capital, they study fossil fuels, minerals, forests, and carbon damage, but not agricultural land and fisheries. Also, their notion of intangible capital is based on the residual of the net present value of consumption that cannot be explained by tangible capital assets. It is not our purpose to extensively discuss the theoretical difference here: for further extensive discussion on the comparison, see IWR 2012 (UNU-IHDP and UNEP 2012)[10].

In principle, they could look similar, but are they empirically different in the assessment of sustainability over the years? Figure 31 a shows correlation of IWI per capita and genuine savings. It would be best if we could express genuine savings as share of wealth-like figures, but World Bank does not publish stock data annually. We instead use the average genuine savings, excluding particulate matter emission, as part of the average gross national income (GNI). For genuine savings and IW per

[10] The methodology of World Bank's genuine savings is delineated in World Bank (2011).

capita (without adjustment), they do not have an evident relationship. In fact, negative relationship can be pointed out for high income countries. However, once IW per capita is adjusted (Figure 31 b), a mildly positive relationship can be found for all income groups, implying that both indices tend to produce similar sustainability assessments, although we still have many country samples in Quadrant II. In a similar manner as the relationship with GDP per capita, we observe few countries in Quadrant IV: very few countries with positive IW per capita have negative genuine savings, but not the other way around. In this sense, IW per capita could be a more conservative indicator of sustainability.

Figure 31 a: Growth rates in IW per capita (IWR2014 approach) vs. genuine savings as share of GNI

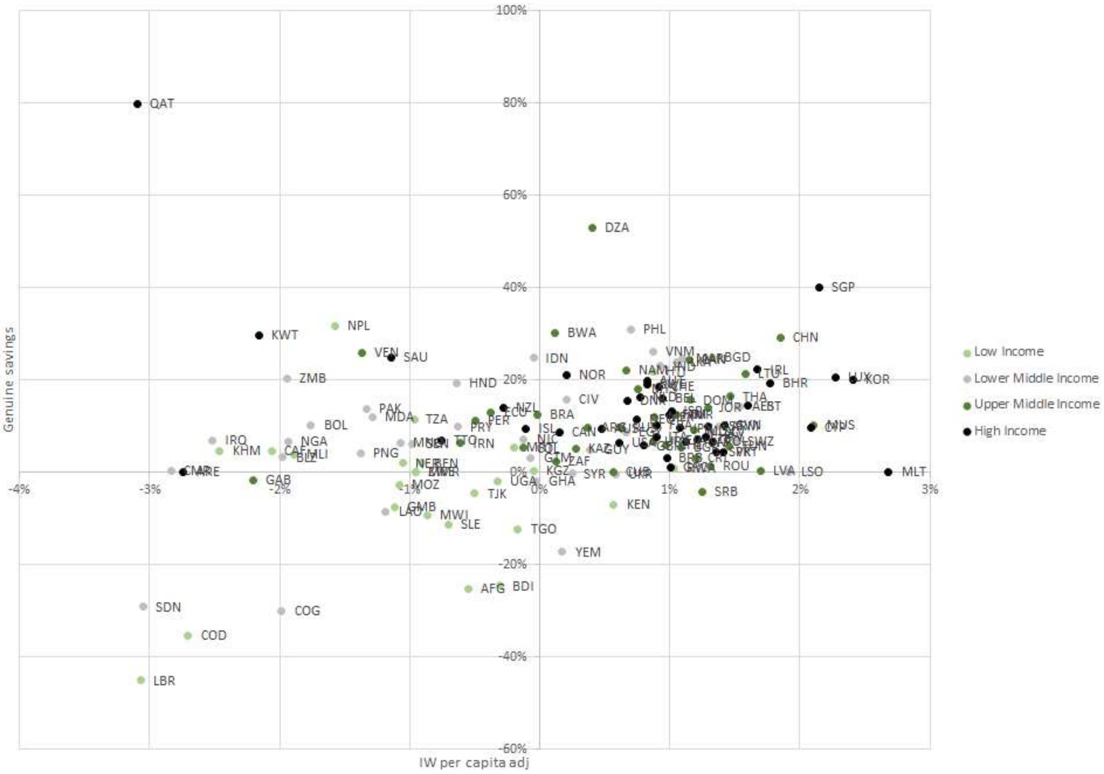
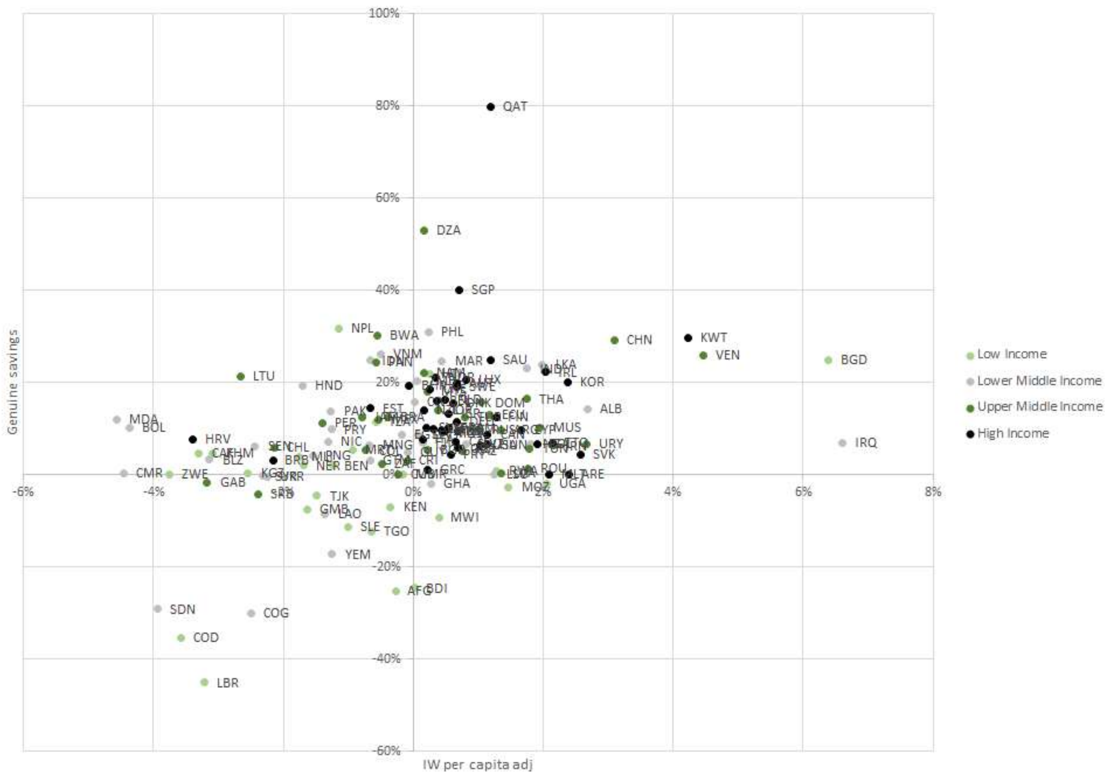


Figure 31 b: Growth rates in IW per capita adjusted (IWR2014 approach) vs. genuine savings as share of GNI



Source: Genuine savings excluding particulate matter emission is expressed as share of GNI, taking the average values of 1990-2014.

5. Final remarks

Sustainability assessment based on capital stocks seems to be here to stay. However, it should be stressed that the equivalence between wealth and well-being is the premise we all should start from. Under such equivalence, the change in well-being should move in the same direction as the change in wealth. Standing on the shoulder of Inclusive Wealth Report (IWR) 2012 and 2014, we continue our effort to show a truer wealth of nations. As we have stressed, it is the change in capital assets and wealth that counts. The value of wealth itself does not have a welfare significance. Nonetheless, the picture of wealth also provides an interesting piece of information.

Specifically, in the current edition of IWR, we showed inclusive wealth of nations, consisting of produced, human, and natural capital, based on a non-parametric method which we call frontier approach. In this approach, shadow prices are so determined that GDP is the output and three capitals are inputs. As it turned out, 135, 89, and 96 out of 140 countries saw an increase when compared to levels in 1990, by inclusive wealth (IW), IW per capita, and IW per capita adjusted. The global growth rate was 44%, which adds up to an average growth rate of 1.8% per annum. However, this is smaller than the annual average GDP growth rate suggests (3.4%) during the same period. Turning to the breakdown of growth, we find that produced capital increased at an annual average rate of 3.8%, while health- and education-induced human capital growth remained at 2.1% and natural capital decreased by 0.7%. In short, investment in produced capital has been facilitated; however, health, education, and natural capital, in which we see an enormous potential for future well-being, either grew in a modest fashion or even decreased. On a global scale, the configuration of capital has been as follows: produced (21%), education (26%), health (33%), and natural (20%). It is remarkable that, of the trio of capitals, the value decreased only for natural capital. A natural way to see this is that produced capital, and to a lesser extent, human capital has been enhanced at a cost of natural capital.

Since some readers may want to see education as human capital using IWR2014 approach where the shadow prices of human capital are based on the rate of return on education, as well as conventional TFP (Arrow et al. 2012), we have also shown results of education computation of capital assets, following IWR 2012 and 2014. According to this approach, for the studied period of 1990-2014, 133, 84, and 81 countries experienced an increase in IW in absolute terms, IW per capita, and IW per capita adjusted, respectively. Since the number of countries and methodology are comparable to previous editions of IWR, these numbers can be said to have improved from 128, 85, and 58 out of 140 countries reported in IWR 2014 for the studied period of 1990-2010. As we do not include health capital in the IWR2014 approach for practical reasons, frontier and IWR2014 approaches are not directly comparable as many would be double counting. Having noted this, the average of the share of capital assets (which is further averaged for the 25-year period) is as follows: produced (17%), human (54%), and natural (29%), with little change from IWR 2014. However, on a different scale, it comes out to be: produced (20%), human (65%), and natural (15%). The latter is an alarmingly low number, highlighting the rising scarcity of nature.

We conclude this chapter by alluding to some of the major challenges and potential discussions.

Completing the list of capital assets. By construction, we are asked to account for many capital assets, provided that they affect intertemporal well-being, and that they do not overlap with existing capital assets. Otherwise, the very premise of equivalent relationship between wealth and well-being would be collapsed[11]. We have included fish wealth as an important constituent of natural capital for virtually the first time. Another class of natural capital that comes to mind is water, which is vital to economies and people of all income categories. As was experimentally discussed in UNU-IHDP and UNEP (2012), water poses a challenge in terms of a tricky relationship between flow and stock variables[12]. In addition, resilience of the nature can be added as another essential capital to economies, at least conceptually (Mäler and Li 2010), and locally in practice (Walker et al. 2009). Accounting for resilience in a non-local manner would be difficult, if not impossible.

[11] If our list of capital assets is not complete, wealth may deviate from well-being. On an empirical front, there has been studies to test genuine savings and consumption change (Ferreira et al. 2008; Greaseley et al. 2014), and we recommend similar studies be taken for inclusive wealth as well.
[12] Fenichel et al. (2016) attempt to account for local groundwater in an imperfect economy.

Furthermore, institutions and social capital are even more challenging classes to reckon. Aside from their intangibility, part of the issue comes from the very nature of those assets: they enable other capital assets to function to yield well-being (Dasgupta 2015). Therefore, we should resist the temptation to just add, say, social capital as another capital asset in an ad-hoc manner, such as valuation of social capital through revealed preference. A more promising way would be to account for social capital in a two-stage setup, where we can see how social capital raises shadow prices of other capital assets.

Shadow prices. Even in imperfect economies as we know, the relative weight of capital assets has been shown to be formalized as their marginal contribution to social well-being, given a forecast of an economy (Arrow et al. 2012), as we demonstrated in Section 2. In the current volume of IWR, we have shown results where non-parametric frontier analysis is used to compute shadow prices of human capital. It comes with its costs: compared to IWR2014 approach of human capital shadow prices, GDP is used as the output corresponding to the three capitals [13]. Inclusive wealth accounting for sustainability assessment is, by construction, founded on intertemporal well-being, so it would be best if we could use the latter as the output. Admittedly, IWR2014 approach is also not without faults: the rate of return on education, as well as value of statistical life (VSL) year, is derived from market transactions; and thus may deviate from the marginal impact on well-being. Perhaps of more concern to us in the face of looming climate change is the non-linearity of shadow prices. We are required to update our shadow prices, if necessary, once scientific evidence on scarcity of components of natural capital is revealed.

Coevolution and interdependence of capital assets. Shadow price of a given capital reflects is marginal social value, but it may also be subject to other capital assets. In the language of ecological economists, capital assets co-evolve. For example, we can think of negative externality on health capital. We already have accounted for carbon damage by greenhouse gases in the adjustment terms, but it may also be an idea to include local air pollution, as is performed for particulate matter in World Bank's (2016) computation of genuine savings. Indeed, there is ample evidence that local air pollution, both indoor and outdoor, is hazardous to health and posing a hindrance to longevity. Local air pollution acts more like a flow variable, rather than a stock, but it could be formalized as a persistent negative natural capital. Even so, care should be taken not to double count with health capital. For if the VSL already captures shorter life years caused by air pollution, then it would be redundant to account for its externality to health.

To give another example, it is not necessarily clear to which capital urban land is allocated; currently it is implicitly within produced capital in many cases. In their analysis of state-by-state

[13] One may defend the usage of GDP as the output of three capitals by claiming that the value of life expressed as health capital implicitly nests future generations. However, this would be a very limited interpretation of utility function, so we do not push this thesis any further.

wealth accounting, chapter 5 of UNU-IHDP and UNEP (2012) has explicitly treated urban land under produced capital. Improving the amenity value of the environment in cities therefore could a potential to boost the shadow value of urban land. Conversely, natural capital shadow price could be affected by produced capital investment. However, this is still open to discussion, since this would involve consumers' surplus, which may not exactly match shadow value in inclusive wealth accounting. This would bring us back, like it or not, to the matter of shadow prices.

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