KYUSHU UNIVERSITY

Measuring sustainability and well-being

INCLUSIVE WEALTH REPORT 2018

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2018 | Measuring Sustainability and Well-Being

PART I: WHAT DOES THE DATA SAY?

CHAPTER 1: ACCOUNTING FOR THE INCLUSIVE WEALTH OF NATIONS: KEY FINDINGS OF THE IWR 2018

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1.1. Introduction

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

In terms of the long-term well-being of an economy, the vast literature on green national accounting shows that net domestic product (NDP) – an adjusted index of GDP – provides a fairly good representation of human well-being (Weitzman 1976; Asheim and Weitzman 2001). NDP is computed from GDP and accounts for changes in capital assets, such as capital depreciation and natural capital depletion.

However, this adjustment is not sufficient for representing intergenerational well-being or the sustainability of an economy. In particular, NDP still includes the portion of the domestic product that is to be allocated to current consumption, which could potentially be excessive. Excluding the value of current consumption from NDP leaves us with investment in produced, human and natural capital – in other words, an Inclusive Wealth Index (IWI) (Dasgupta *et al.* 2015).

What makes our index and that of the World Bank's genuine savings indicator distinct from GDP is obvious.[10] It is calculated from stocks, rather than flows; it measures determinants, rather than constituents of well-being (Dasgupta 2001). For the latter, it is more a matter of subjective well-being – i.e. happiness and life satisfaction (Helliwell *et al.* 2017; Easterlin 2003; Kahneman *et al.* 2006; Layard 2005) – and objective outcomes of well-being, such as the Better Life Index (OECD 2014). The Human Development Index (UNDP 1990-2016) is a composite index of education and health, in addition to GDP. It is a commendable innovation in that it has shifted the focus towards human capital aspects of well-being.

Another strand of the literature arguing to abandon 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, labour, 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 that includes consumption, leisure, mortality and inequality fronts. They found that these data are highly correlated with GDP per capita, with some deviations. While the aspects that they address are, without doubt, important, our focus in more on the long-term sustainability of determinants of human well-being – which leads us to the construction of a capital-based indicator.

Of course, no single index can measure every aspect of human well-being, and the IWI is no exception in this regard. Note, in particular, that our IWI says little about the extent to which current well-being is achieved in practice, partly because the score of current capital stocks is not fully consumed by contemporaries and because the IWI is, by construction, a determinant- or opportunity-based indicator. It is not meant to be something that can explain the outcomes and constituents of well-being. In principle, the IWI should include a sufficiently broad, ideally exhaustive, but not redundant, score of capital assets that is relevant to current and future human well-being. While classical economics focused on (produced) capital, labour and land, neoclassical economics has treated capital and labour as part of the production function. Subsequently, the economics of exhaustible resources included capital and non-renewable resources (Dasgupta and Heal 1974; Solow 1974). In mainstream economics, human capital – the capitalized concept of labour – has also played an important role in how economic growth can be decomposed (Mankiw *et al.* 1992). For the sustainable development of well-being, we must include natural capital – a broader notion than natural resource stock alone. Thus, we have come full circle, to our ultimate set of capital stocks (or productive bases): produced, human and natural capital.

10 See UNU-IHDP and UNEP (2012) for what makes the Inclusive Wealth Index distinct from the World Bank's genuine savings. To be more precise, genuine savings are constructed from flow variables, complemented by stock calculations.

Fig 1.1: A three-capital model of wealth creation

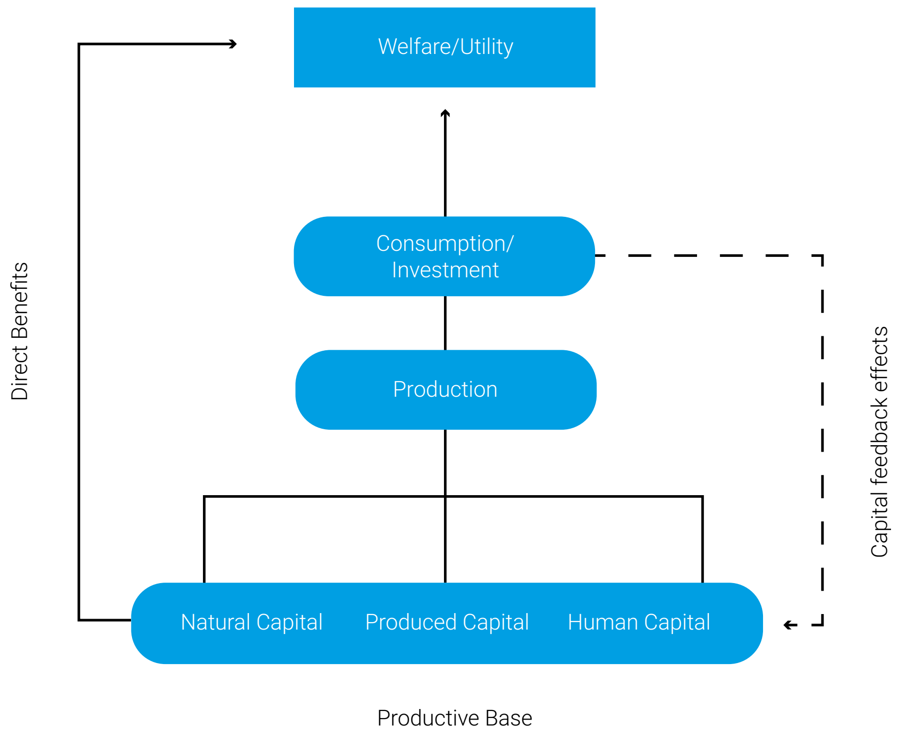


Fig 1.1 shows how these three capitals lead to the ultimate purpose (if any) of an economy: social well-being. The three capitals are inputs into the production system; thus, they are called the *productive base* of the economy. Produced capital is the easiest to imagine and includes roads, ports, cables, buildings, machines, equipment and other physical infrastructures. Human capital consists of population (size and composition); knowledge and skills acquired by education; and health (enhancing quality of life, extending life and boosting productivity). For natural capital, the current accounting addresses subsoil non-renewable resources, forests and agricultural land; ideally, it should also include ecosystems in general.

Along with these three familiar capital assets, our first edition (UNU-IHDP and UNEP 2012) noted that knowledge, population, institutions and even time could be conceived as capital assets. Dasgupta (2015) called them *enabling assets*, in the sense that they enable the three capital assets to function well and, ultimately, improve social well-being. Formally, they could increase the shadow prices of capital assets.

Unconventional forms of capital include the following: institutions (property rights, firms, government, households); knowledge (natural laws, algorithms, theorems, cultural narratives); social capital (the law, social norms, habitual practices); and time (exogenous changes experienced by society over time). While including these capital assets would be commendable, they remain elusive as they currently stand. Changing institutions reveal themselves in how capital assets are employed to improve social well-being; thus, they could be a determinant of the shadow prices of capital assets. Time as an asset represents the value of waiting, including Solowian technological progress, resource price movements, population changes and other exogenous shocks to the economy in question. The IWR 2014 and our edition of this IWR 2018 address all of these terms in the adjustments to the IWI: namely, population change, total factor productivity (TFP), oil capital gains and carbon damage. As such, time as an asset is addressed in our framework. Once we establish 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 the accumulation of the productive base, which in turn improves future well-being. This fundamental trade-off between consumption and investment has been a classic problem of optimal saving, dating back at least to Ramsey (1928). However, in the context of sustainable development, economies should strike a balance between consumption and investment, the latter including the degradation (negative investment) of natural capital.[11]

Some studies have suggested that capital stocks have a direct effect on utility, circumventing the consumption channel. For example, air pollution or climate change can cause disutility, for which increased consumption cannot be a substitute (Krautkraemer 1985; Xepapadeas 2005; d'Autume and Schubert 2008). It is not uncommon in climate change modelling to

11 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.

assume that climate directly affects utility (van der Ploeg and Withagen 2014). It is for these reasons that we present an alternative route from productive base to welfare in Fig 1.1.

It is important to note that the absolute value of wealth per se is of little interest to us. Only the comparison of wealth across time or space (nations) is significant in terms of welfare. Asheim (2010) showed that net national product (NNP) per capita is a useful index for the purpose of welfare comparisons across different countries. However, we must resist the temptation to compare the absolute value of inclusive wealth (IW) (per capita); our interest should lie in the change in IW per capita over time.

This year's report advances and expands on our first and second editions of the IWR. First, our rich sample continues to track the 140 countries sampled in IWR 2014, compared with only 20 countries in IWR 2012. The data set now represents a sizeable proportion of world GDP (US$56,835 billion) and of the global human population (6.885 billion). Second, the studied time period has also expanded by five years, to a quarter of a century (1990–2014), which provides us with a picture of the changes in capital assets over almost a generation. Third, our data set of natural capital now includes one of the most significant renewable but mobile resources: fisheries. This inclusion adds to our collection of renewable resource natural capital, which already included forest resources and agricultural land in IWR 2012 and 2014. IWR 2012 included some discussion of the fishery resources of four countries for the time period 1990–2006, based on 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 that includes many more countries (Sugiawan *et al,* 2017). Fourth, the methodologies for calculating components of human capital have been 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 refer to it as the *frontier approach*. This approach is contrasted with that adopted in IWR 2012 and 2014, following the literature on pricing human capital using a lifetime income approach.

The remainder of this introductory chapter is organized as follows. In Section 2, the basic idea and methodology behind the IWI are introduced. Further details regarding the architecture of the index are contained in the Methodological Annexes. Section 3 presents the 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 agreed methods for human capital (education) calculation, consistent with the traditional interpretation of the rate of return on education and the IWR 2014 results. Section 5 summarizes our results, explains some limitations of the current methodology and addresses some concerns and potential criticisms of the IWI in general.

1.2. Methods

In this section, we outline our underlying framework, which is based on the literature on green accounting, particularly pertaining to imperfect economies (Arrow *et al.* 2012). We note that the economy's objective is sustainable development, in the sense that intertemporal well-being, V, at time, t, which is a function of consumption, C, is not declining:

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

This expression is merely a discounted sum of instantaneous welfare depicted in Fig 1.1. 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 IW 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 ensure 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_N 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 only the passing of time directly affects well-being. The shadow prices are essentially marginal contributions to the 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 weighting factor attached to each form of capital, resulting in the measure of wealth, or IWI:

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

In practice, *W* and IWI can be used interchangeably.[12] For sustainability analysis, what we need is the change in capital assets or what we can 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, which we elaborate on later – we omit 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 is sufficient 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 changes in IW.

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

However, if there is a significant perturbation, such as the implementation of a large project, a natural disaster or a financial crisis, we must account for the change in shadow prices, even within a short time period. We should consider the price change – capital gains on any capital asset – seriously because we will accumulate our editions of the IWR in the years ahead.

One exception to this rule (constant shadow prices assumed over the studied period) is oil capital gains. Oil prices, or commodity prices, are notorious for fluctuations within relatively short time periods. Even if the quantity of oil within a nation does not change, a spike in the oil price means that the country can cash in its oil wealth and increase consumption and investment in IW. This is particularly pertinent to oil-rich nations in the Middle East, which are seeking to develop alternative economic bases and reduce their reliance on oil-related industries. Nurturing an industry from scratch takes a long time. Conversely, net oil-importing countries tend to experience a deterioration in social well-being as a result of rising oil prices. We account for this loss of opportunity by allocating 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 *Pn* to change, we have

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

which represents our capital gain adjustment.

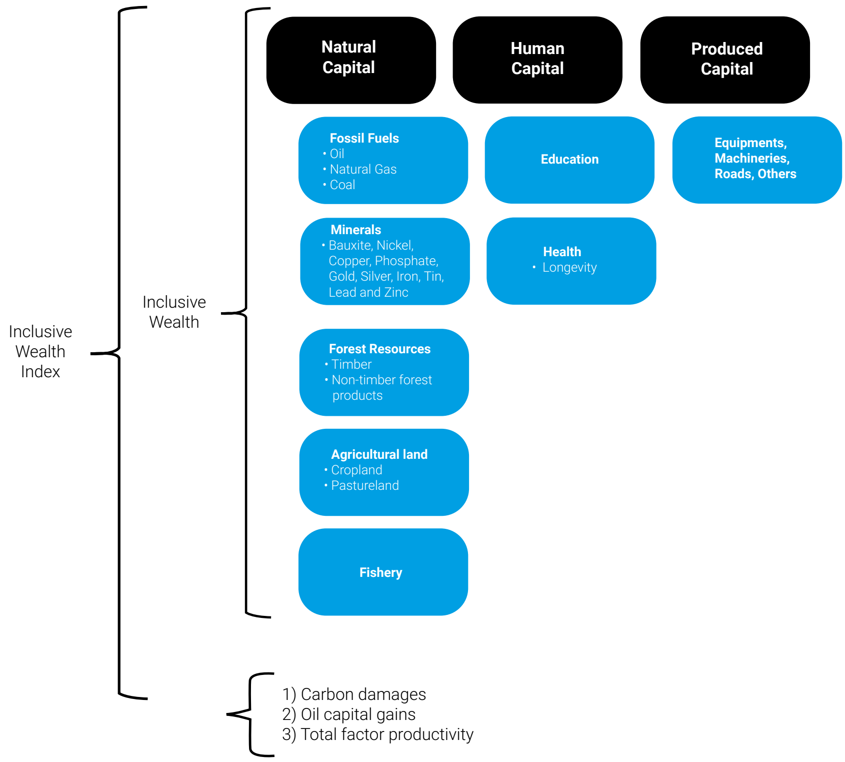
Aside from oil capital gains, there are other important adjustments that need to be taken into account. How capital assets are employed and utilized to yield social well-being can change over time – for example, through enhanced productivity, technological progress or improvement in trust and social capital. In practice, however, all of these factors can be captured by the change in TFP – insofar as social well-being improves (or deteriorates) more than the individual contributions of capital assets increase (or decrease). Arrow *et al.* (2012) showed that, in terms of accounting, all that we need to do is add the TFP growth rate to the inclusive wealth growth rate.

Finally, there is another aspect of the natural environment that needs to be considered in the coming centuries. Increasing carbon emissions are predicted to cause climate change, which will endanger many lives and lead to other forms of potentially devastating socio-economic damage. Current economic activity is reducing the carbon sink stock of our planet – which could conceivably count as another capital asset in IW. Alternatively, we can tap into the ongoing and increasing research on the social cost of carbon, which can be used to value the damage done to social well-being by additional emissions of carbon. In this report, we continue to adopt the latter approach. In particular, the total global emissions of carbon are evaluated using the social cost of carbon, which is then allocated to individual countries according to the share of the global damage done; this is then subtracted from the IW of nations.[13]

Fig 1.2 provides our schematic representation of how our three key capital assets, as well as adjustment factors, shape our final index of IW. Along with the familiar capital assets that we consider from previous reports (IWR 2012 and 2014), this report adds the fishery resource stock to the list of natural capital. In the ensuing sections, we report many aspects of the aggregated figures of the IWI, both before and after adjustments. To avoid confusion, in section 3, we focus on IW based on the frontier approach, which uses a non-parametric valuing of education- and health-induced human capital. Produced and natural capital are computed in a similar manner to the approach used in IWR 2012 and 2014. In section 4, we extend the conventional approach inherited from IWR 2012 and 2014. For human capital, we account only for the education-induced portion. For further notes on the different methodologies, readers are advised to examine the Methodological Annexes.

13 More specifically, the ratio of carbon damage to inclusive wealth can be deducted from the inclusive wealth growth rate to arrive at the adjusted inclusive wealth growth rate.

Fig 1.2: Schematic representation of the Inclusive Wealth Index and the Adjusted Inclusive Wealth Index.



1.3. The Inclusive Wealth of Nations

1.3.1. Measuring performances based on changes in wealth

In this subsection, we evaluate countries' sustainability conditions over the past 25 years by calculating human capital, including both education and health shadow prices, using the frontier approach. The sustainable growth of nations is evaluated by analysing changes in the IWI. We show the changes in IW, both in absolute and per capita terms, for 140 countries over the past few decades.

The results show that the growth of IW is positive for a considerable number of countries. However, for a significant number of countries, the growth of wealth is slower than the population growth, resulting in a negative per capita growth of wealth. In addition, some of the negative per capita growth of wealth occurred in countries that experienced absolute gains in wealth. The changes in countries' wealth are calculated using annual average growth rates over the past 25 years, with 1990 as the base-year.

Our estimation results show that 135 of the 140 countries assessed in the IWR 2018 experienced growth in inclusive wealth (before adjusted factors) (Fig 1.3 a). On a per capita basis, 89 of the 140 countries (64 percent) show positive rates of growth in the IWI (Fig 1.3 b).

Fig 1.3: Annual average growth rate in IWI and IWI per capita before adjustments for 140 countries, annual average for 1990-2014

Fig 1.3a: Annual average growth rate of Inclusive Wealth Index.

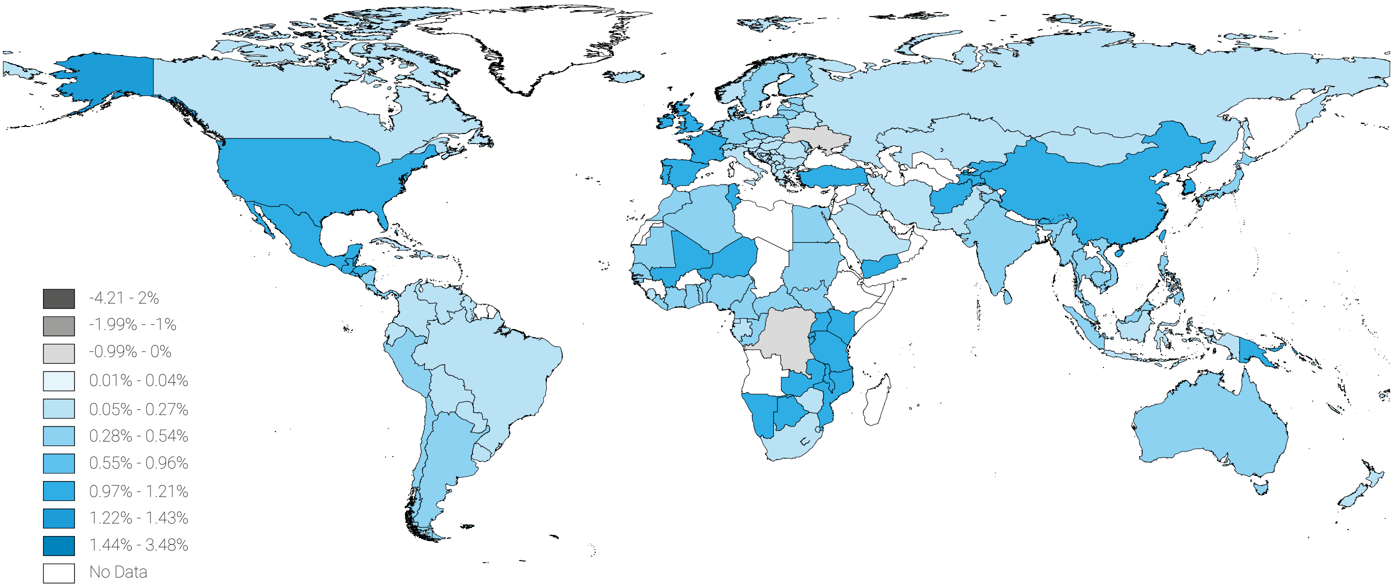
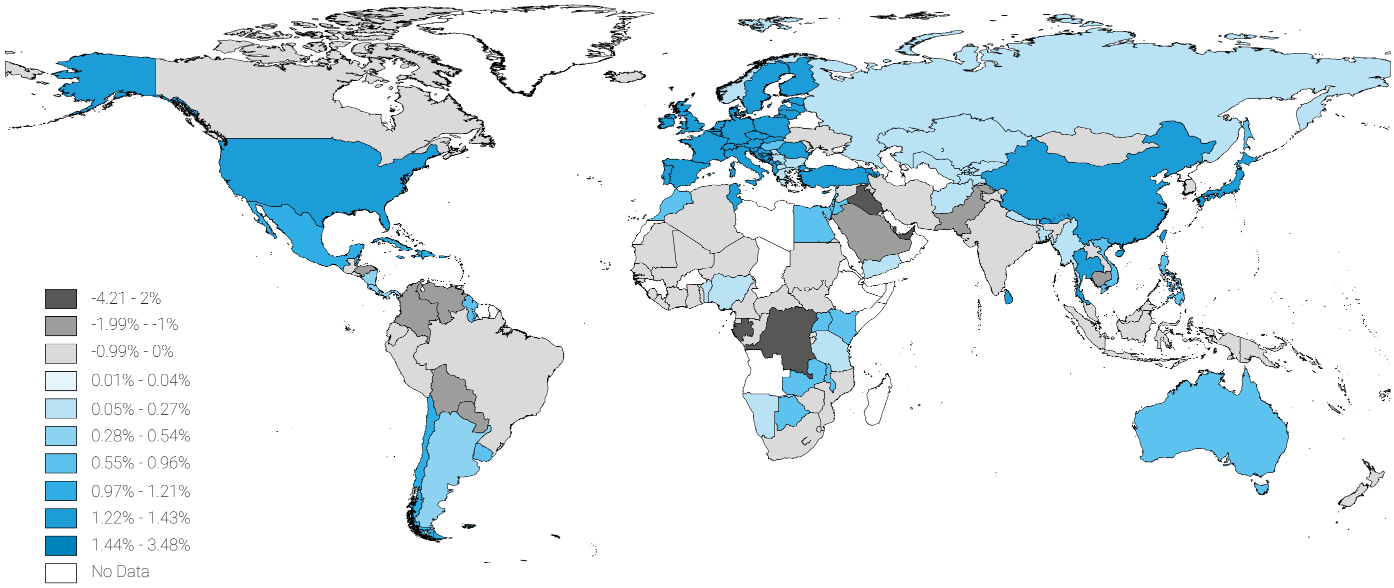


Fig 1.3b: Annual average growth rate of Inclusive Wealth Index per capita



When the IWI includes the adjustments for TFP, carbon damage and oil capital gains, 124 of the 140 countries showed a positive growth rate (Fig 1.4 a). In a per capita analysis, 96 of the 140 countries (69 percent) experienced positive IWI growth rates after adjustments (Fig 1.4 b).

Fig 1.4: Annual average growth rate in IWI and IWI per capita after adjustments for 140 countries assessed in the IWR 2018 from 1990 to 2014

Fig 1.4a: Growth in Inclusive Wealth Index (adjusted)

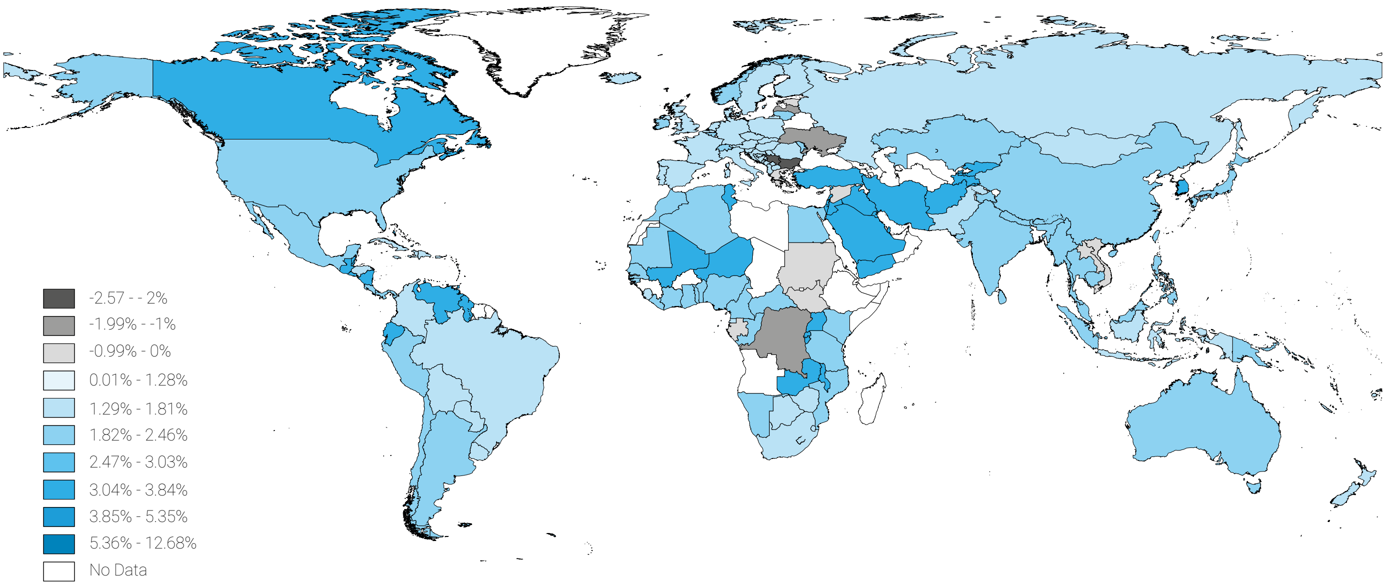
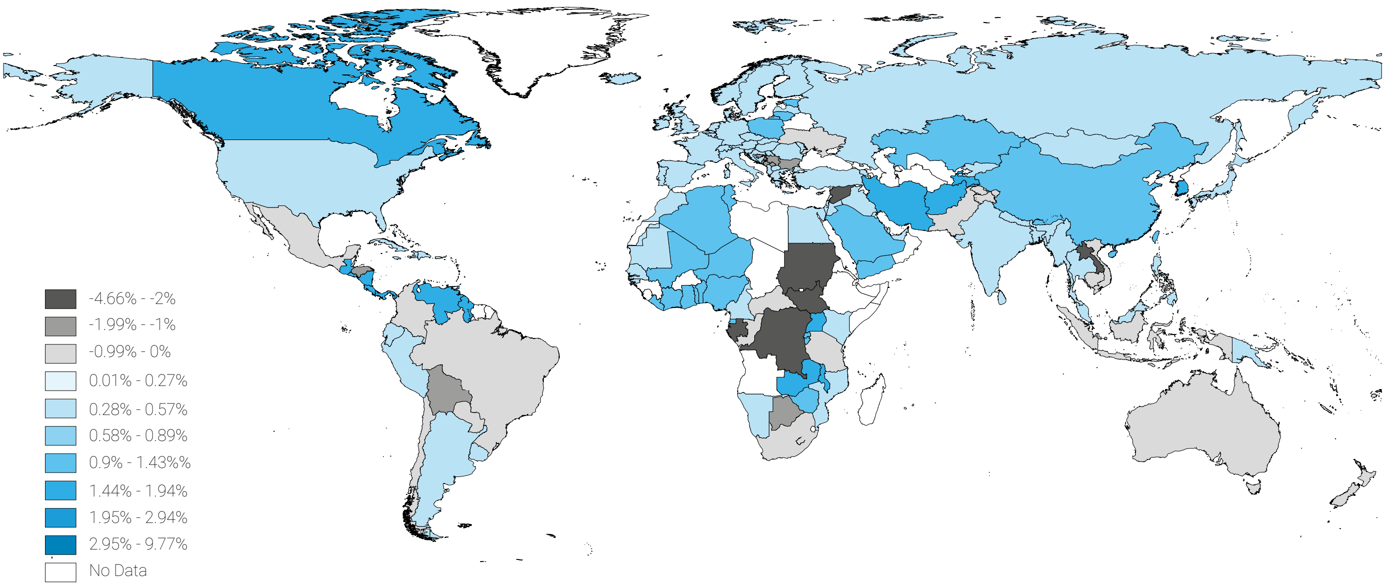


Fig 1.4b: Growth in Inclusive Wealth Index per capita (adjusted)



We investigate the inclusive wealth (IW) growth of countries and regions in Fig 1.5a. Three countries can be identified in Quadrant III: the Democratic Republic of Congo, Trinidad and Tobago, and Ukraine. All three experienced negative growth rates in both absolute and per capita terms. Two former Soviet-allied countries – Bulgaria and Moldova – *improved* their performance when population is considered in the index because both countries have had declining populations over time (Quadrant II of Fig 1.5a). The decrease in the population in these countries meant that more resources became available for each person compared to the base-year. Of the 135 countries with positive absolute growth in wealth (Quadrant I and IV), 87 also experienced per capita growth in wealth (Quadrant I). For the remaining 48 countries, the decrease in wealth per capita (Quadrant IV) could be interpreted as a result of underinvestment in light of their population growth.

We also identify the IW growth rates of countries after the three adjustments to the IWI in Fig 1.5b. Fifteen countries are assessed as unsustainable according to the adjusted IW per capita: Bulgaria, the Democratic Republic of Congo, Gabon, Gambia, Greece, Croatia, Haiti, Jamaica, Laos, Latvia, Sudan, Serbia, Syria, Ukraine and Viet Nam. Quadrant III of Fig 1.5 b shows countries with negative growth rates, both in absolute and per capita terms.

Estonia is the only country that improved when population is considered (Quadrant II). Of the 124 countries with positive absolute growth in adjusted IW (Quadrant I and IV), 95 also experienced growing wealth per capita (Quadrant I). The remaining 29 countries witnessed a decline in wealth per capita.

Fig 1.5: Annual average growth rate in IW and IW per capita

Fig 1.5a: Annual average growth rate in IW and IW per capita (unadjusted)

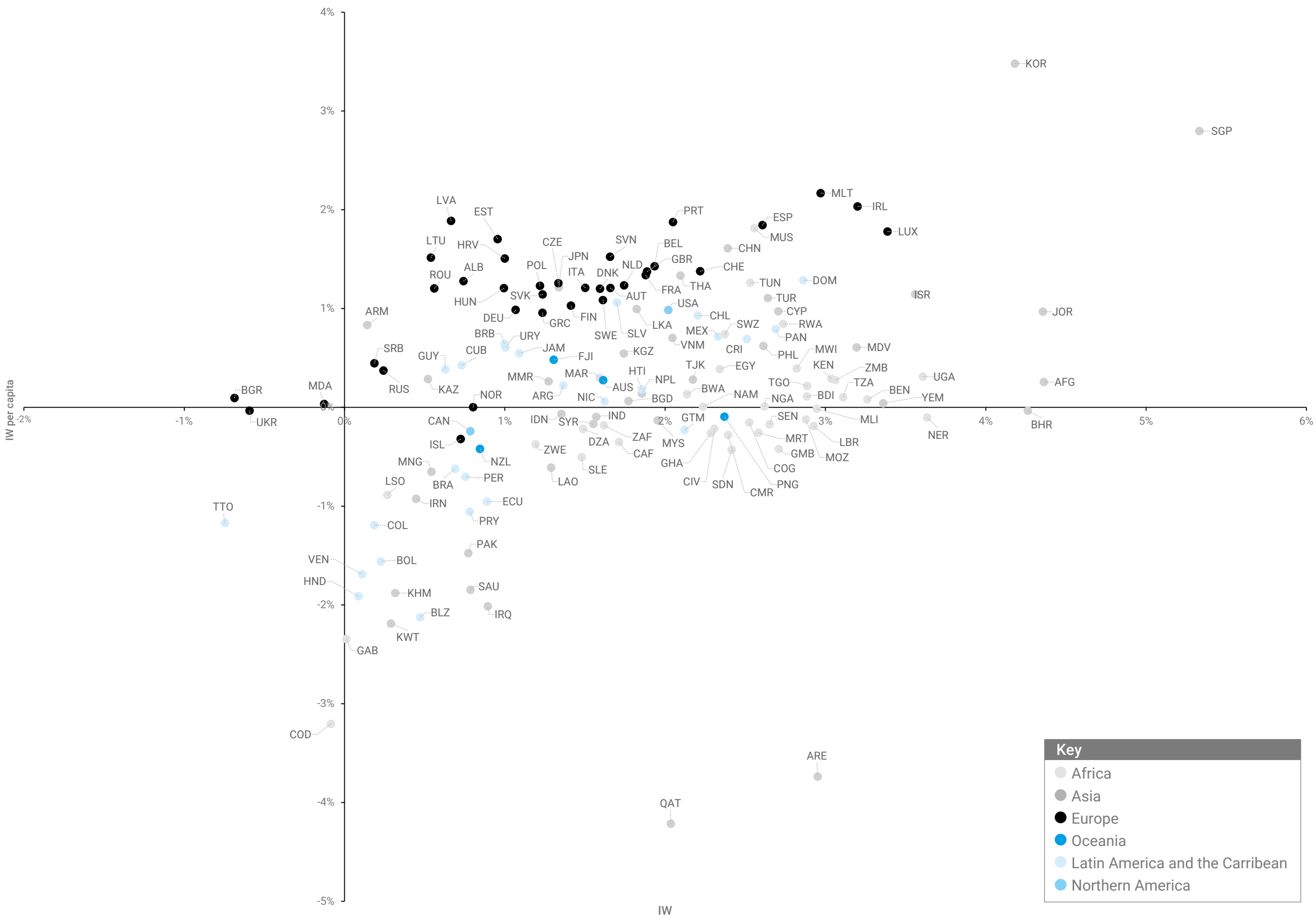
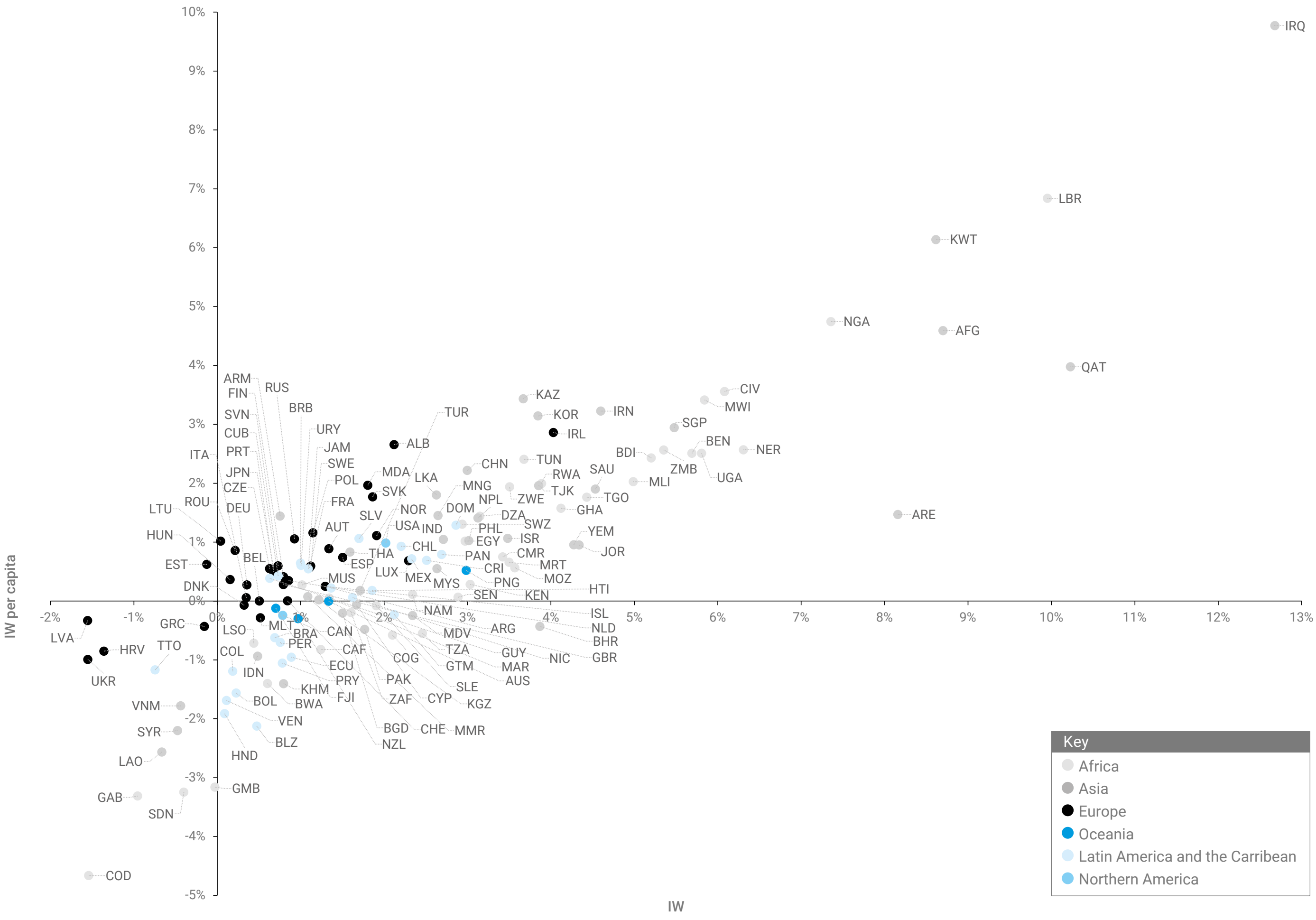


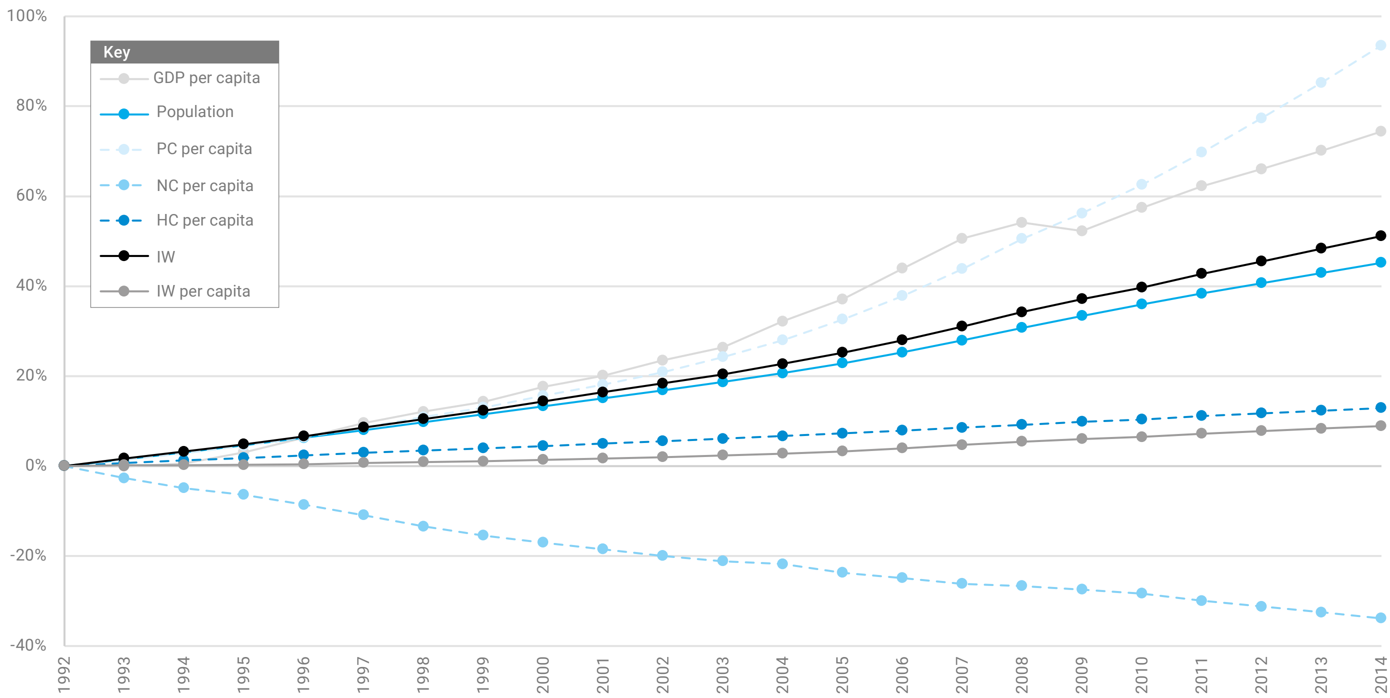
Fig 1.5b: Annual average growth rate in IW and IW per capita (adjusted)



1.3.2. Changes in the global composition of wealth

The global change in IW in absolute and per capita terms is critical for evaluating the performance of the global economy. We calculate the changes in IW and per capita IW in international dollars using purchasing power parity (PPP) exchange rates. These data are the aggregated wealth of all nations from 1992 to 2014. The results are illustrated in Fig 1.6. Changes in global wealth were largely positive from 1990 to 2014. The major positive changes were in produced capital, followed by human capital. In contrast, natural capital experienced a significant decline from 1992.

Fig 1.6: Changes in worldwide inclusive wealth per capita and other indicators for 1992–2014



1.3.3. Wealth composition

In this section, we discuss the composition of the wealth stock of nations. The composition of national assets are shown in Fig 1.7, which illustrates the relative importance of each type of capital. Human capital is the dominant form of capital for 93 of the 140 countries evaluated. Furthermore, for the majority (77) of these 93 countries, human capital made up 50 percent or more of the total capital assets.

Natural capital, on the other hand, is the most important source of wealth for 21 countries. Interestingly, 16 of the 21 natural capital-abundant nations are low-income or middle-income economies. Natural capital is an important source of wealth in South America, Central Africa and Western Asia.

For 19 countries, produced capital is the main source of capital. All of these are high-income countries and located in Europe, North America and East Asia.

Fig 1.7: Percentages of natural, produced and human capital in total wealth – annual average for 1990–2014

Fig 1.7a: Percentage of natural capital in total wealth

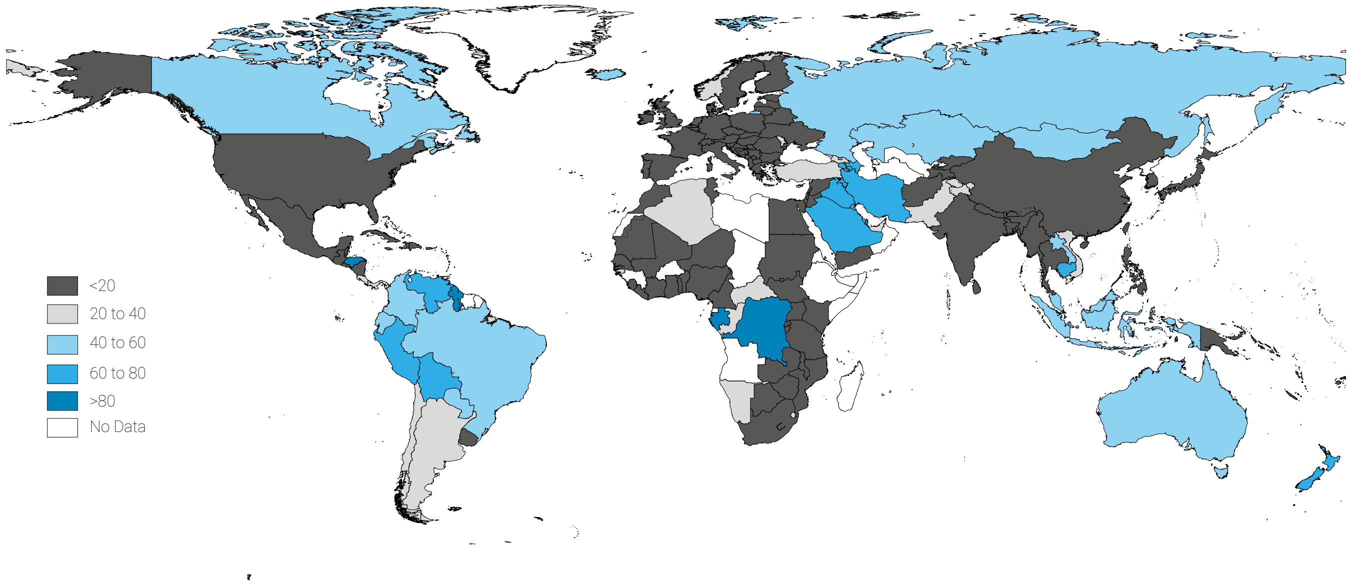


Fig 1.7b: Percentage of produced capital in total wealth

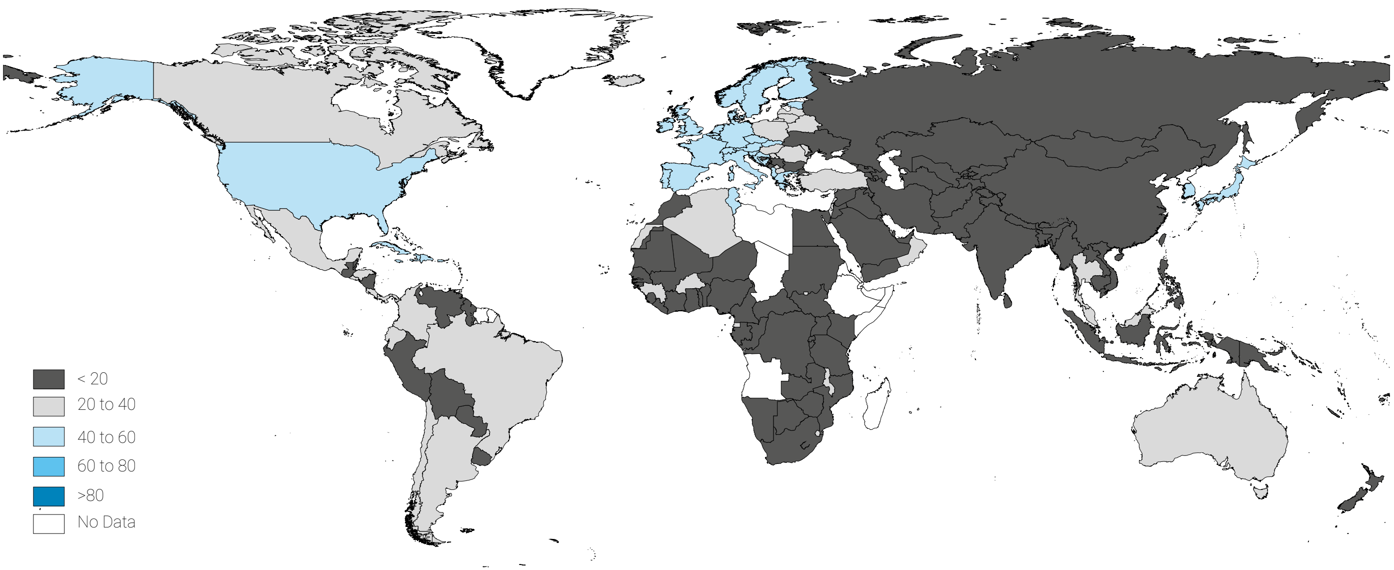
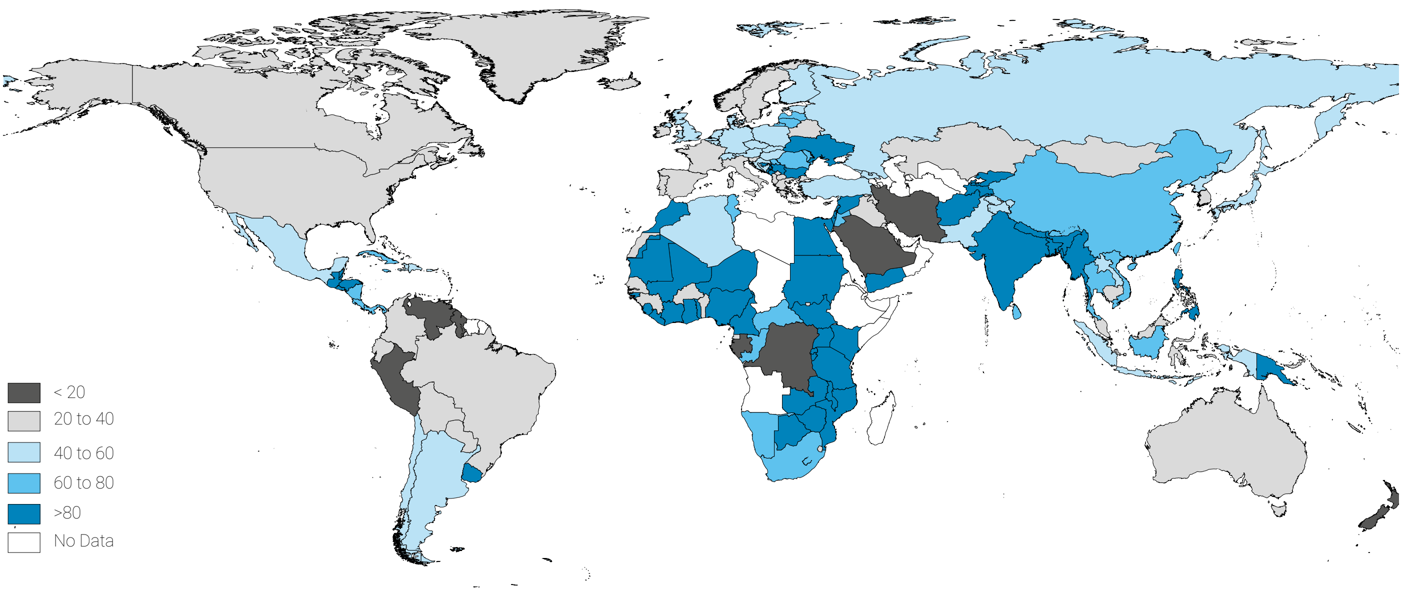


Fig 1.7c: Percentage of human capital in total wealth



We also explore the overall composition of capital on the global level. Fig 1.8a clearly demonstrates the importance of human capital, which represents 59 percent of total wealth.

Changes in the composition of the capitals over time show that, while the average contributions of human and produced capital to the total capital increased, the share of natural capital declined, as shown in the crossing line in Fig 1.8b.

Fig 1.8: Developments in the composition of wealth by capital from 1990 to 2014

Fig 1.8a: Average wealth compositions across countries (mean 1990–2014)

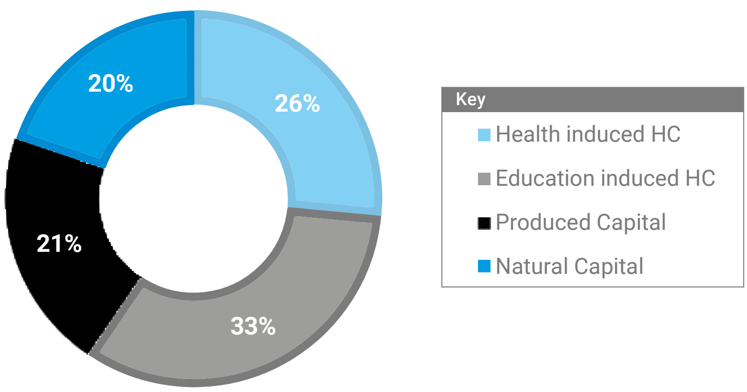
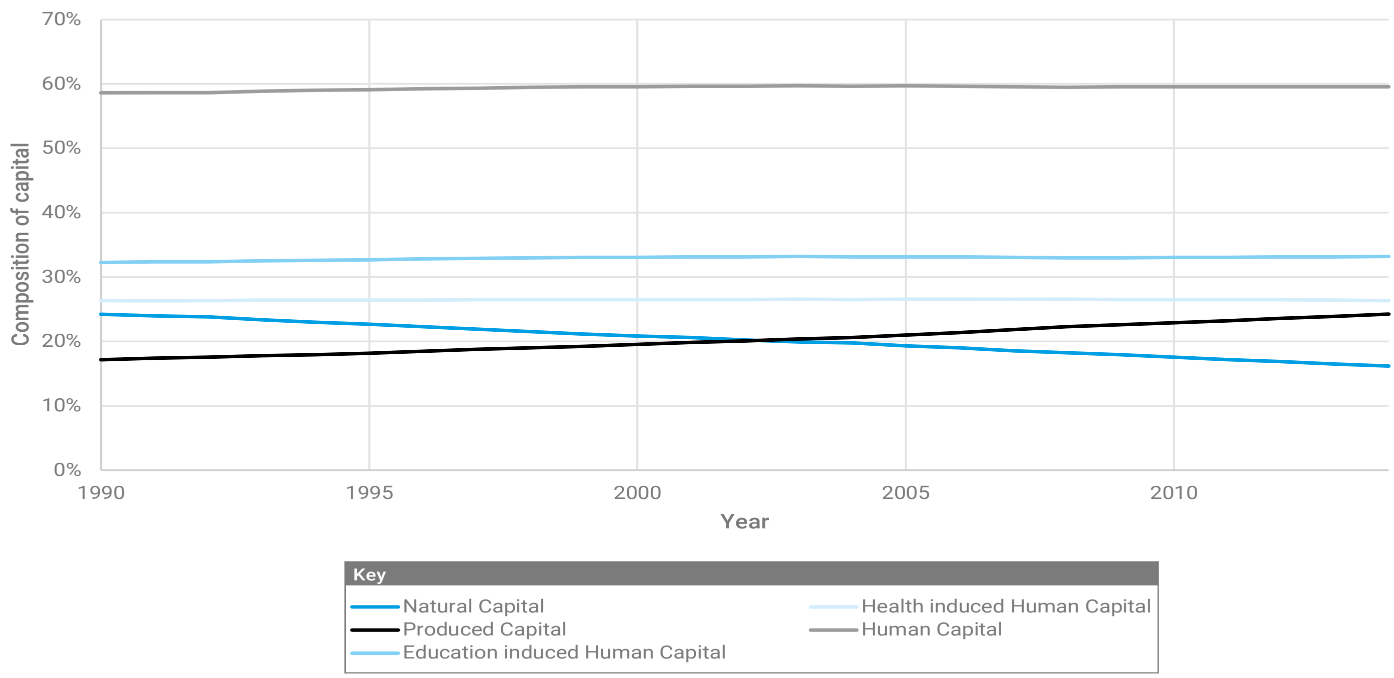


Fig 1.8b: Developments in the country average wealth composition



1.3.4. IWI adjusted

In this subsection, we investigate the performance of IW, after considering three factors.

1. Carbon damage: the damage from climate change, due to the increased impacts of carbon concentrations in the atmosphere
2. Total Factor Productivity (TFP): exogenous factors that impact economic growth
3. Oil capital gains: the changes in oil prices and the value of the productive base

The adjustment factors can affect the IW of nations either positively or negatively. If oil prices increase, oil-producing countries benefit, while oil-importing countries experience a loss. TFP can also impact either way; less efficient use of resources will cause negative productivity in the subsequent year (Managi, S. 2011, Kurniawan, R. and Managi, S. 2011).

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

In terms of oil capital gains, 113 of the 140 countries suffered from increasing oil prices. The remaining 27 countries experienced positive impacts. Six oil-abundant countries, mainly in the Middle East, gained at least 4 percent from increasing oil prices: Venezuela, Iraq, Qatar, Kuwait, Saudi Arabia and the United Arab Emirates.

Finally, TFP growth rates were positive for 87 countries and negative for 53 countries. The average growth of TFP ranged from +7 percent to -3 percent and had significant impacts on several countries. Malaysia, for instance, moved to a positive per capita growth following IW adjustment, primarily due to positive TFP growth. In contrast, Serbia moved to negative IW per capita adjusted, mainly due to negative changes in TFP.

Fig 1.9: Annual average growth of the adjustment factors in 1990–2014

Fig 1.9a : Average growth rate of oil capital gains in 1990–2014

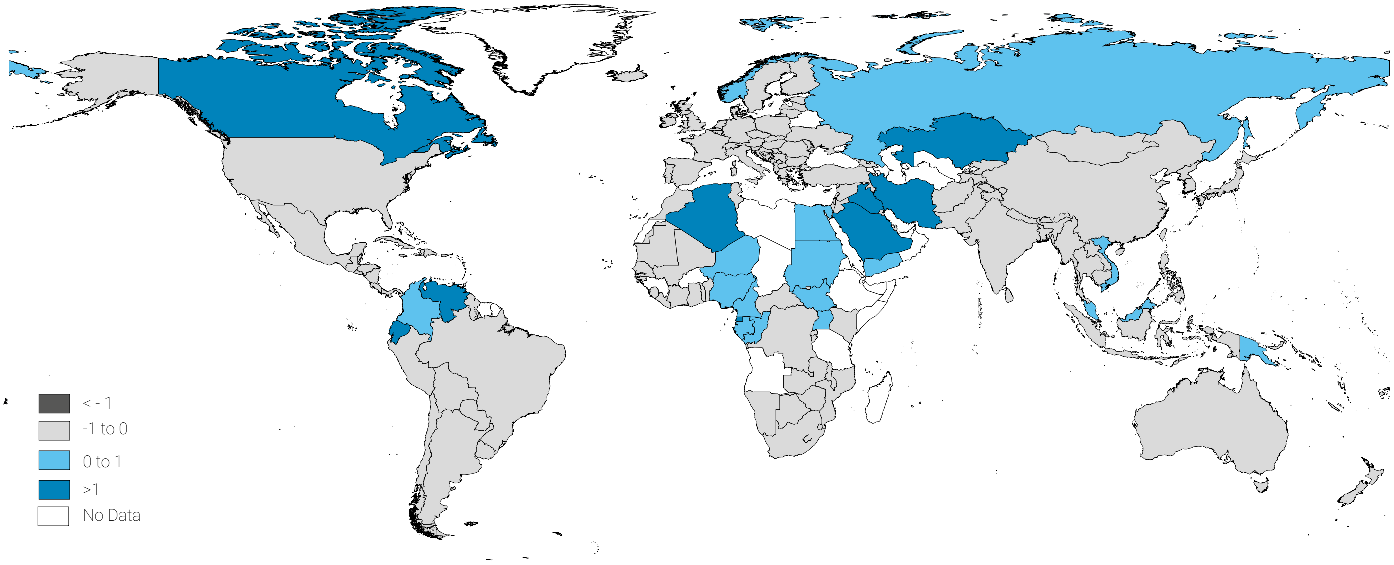


Fig 1.9b: Average growth rate of total factor productivity in 1990–2014

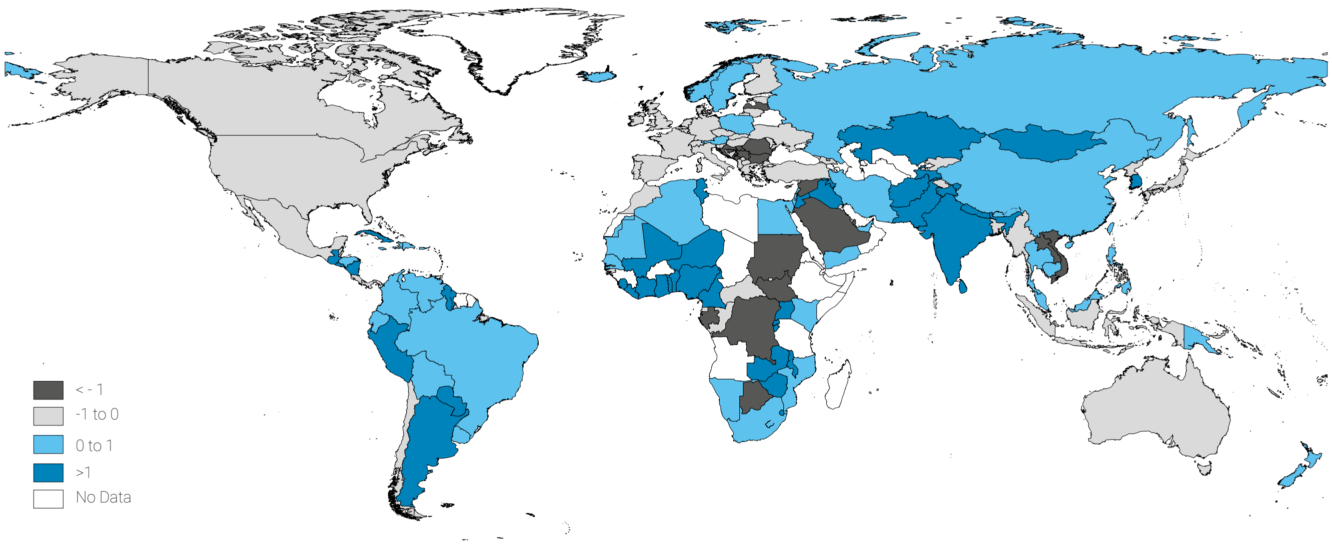
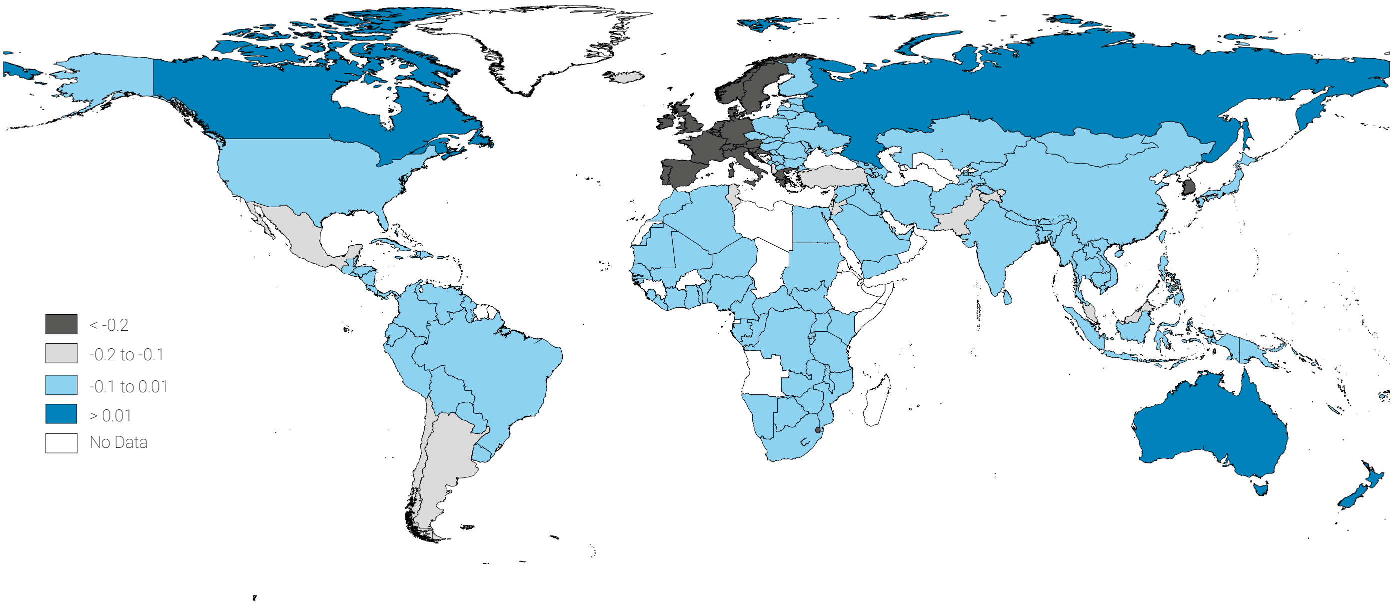


Fig 1.9c: Average growth rate of carbon damage in 1990–2014



1.3.5. Measuring economic performance: comparison of inclusive wealth, GDP, HDI and happiness

There are a number of indicators for evaluating nations' economic and social performance. Three of the commonly used indicators are GDP, the Human Development Index (HDI) and happiness. GDP measures the market value of final goods and services in an economy over a period. HDI measures the well-being of nations by considering education, life expectancy and income. Happiness, although measured in many ways, basically evaluates people's subjective satisfaction by considering factors such as freedom, social support, life expectancy and corruption, among others. Fig 1.10 provides an overview of countries' annual average growth rates of GDP per capita, HDI and IW per capita, over the period 1990 to 2014.

We find positive growth of IW per capita for 89 countries and negative growth for 51 countries. We identify positive IW growth for 97 countries, while for HDI, 139 of 140 countries show positive growth. Thus, the IW per capita paints a more a pessimistic picture of progress than the HDI. In terms of GDP, 128 of 140 countries indicate positive growth rates over the past 25 years. This is clearly different from the picture shown by the IWI or other indicators of sustainability.

Fig 1.10: Average annual growth rates of IW per capita, GDP per capita and HDI, 1990–2014

Fig 1.10a: IW per capita

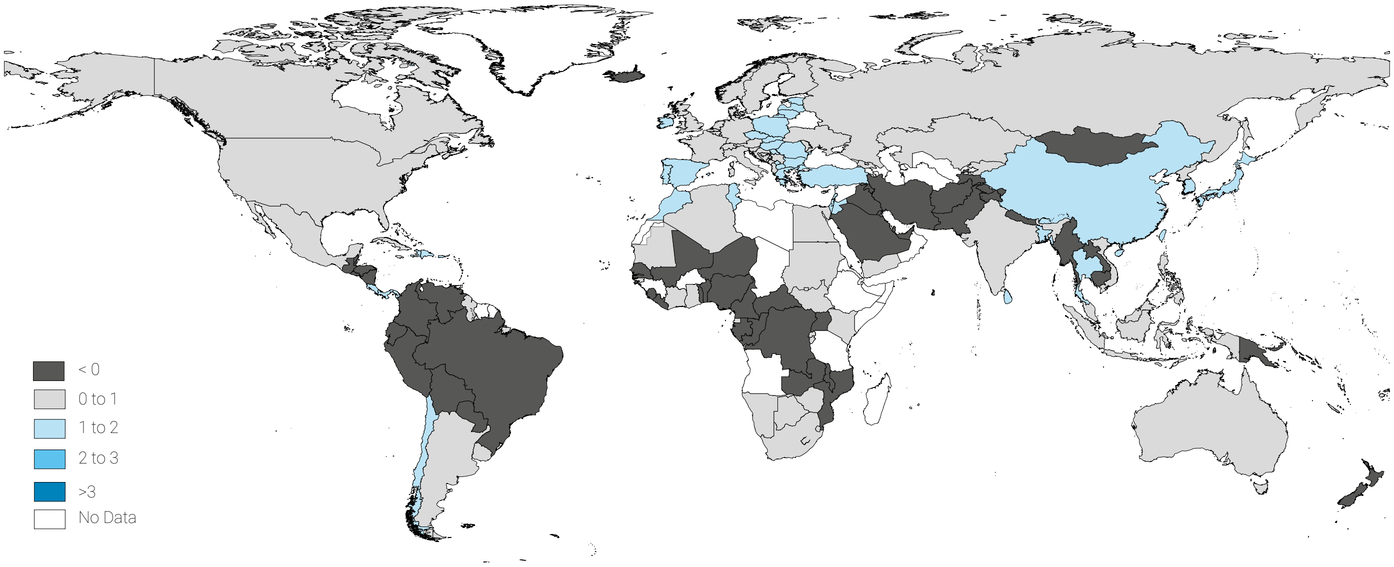


Fig 1.10b: GDP per capita

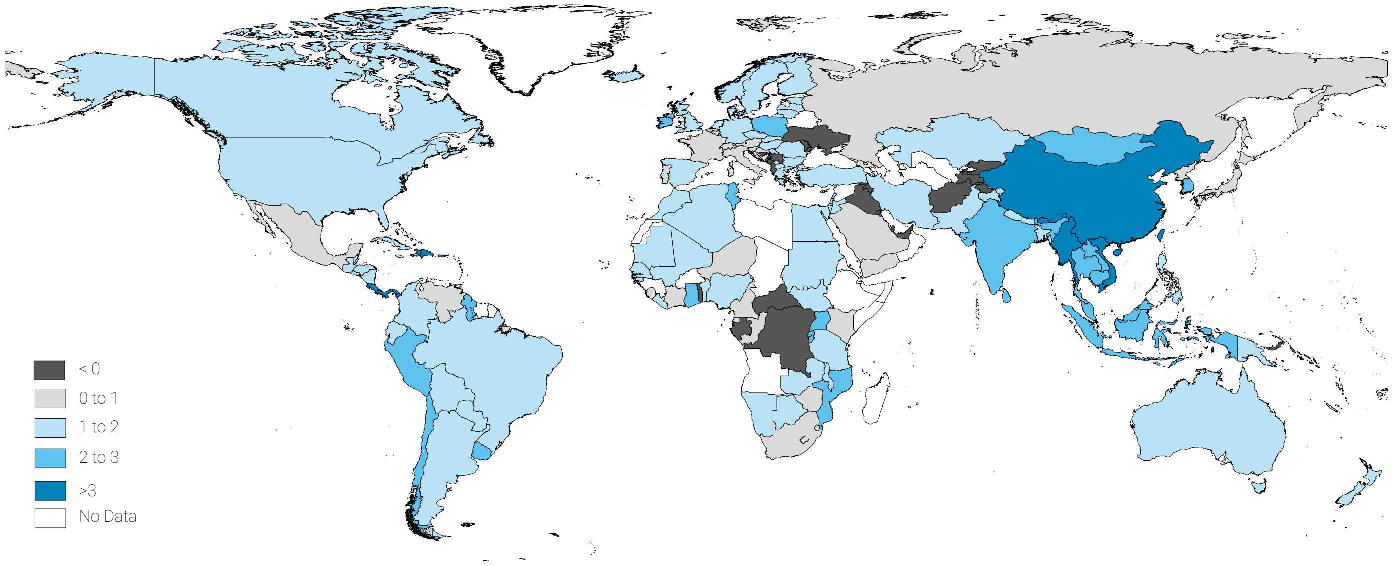
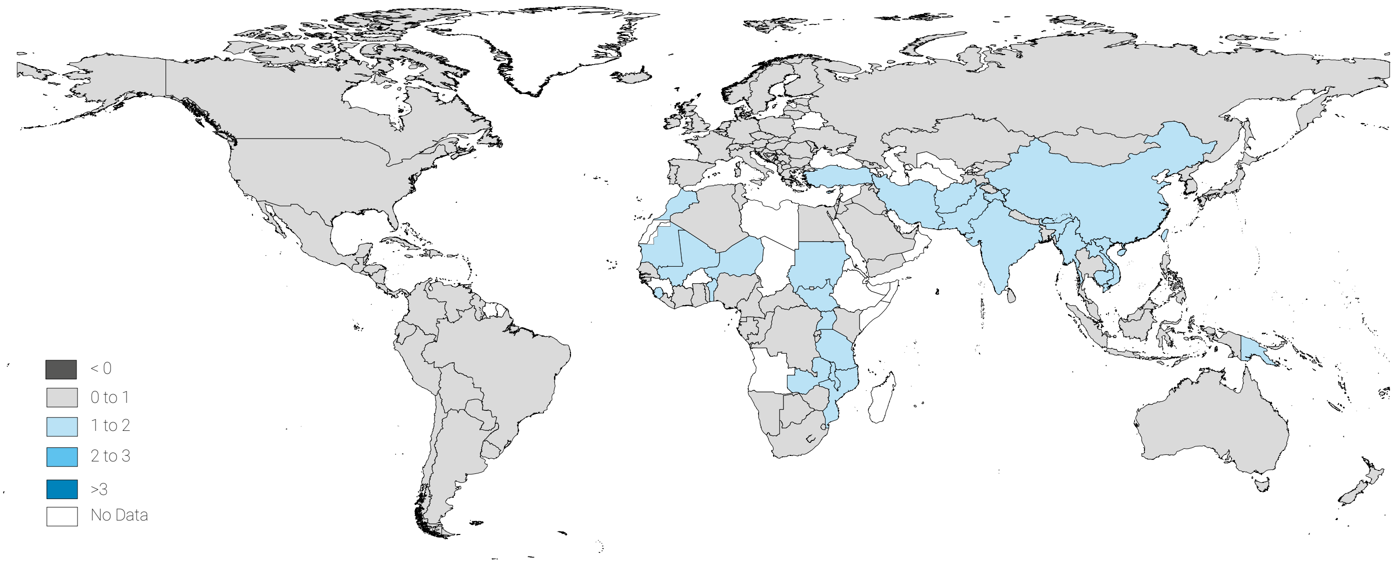


Fig 1.10c: HDI



1.4. The Inclusive Wealth of Nations: Education as Human Capital

1.4.1. Measuring performance based on changes in wealth

This section illustrates the inclusive wealth of nations following the approach used in IWR 2012 and 2014. This is based on the idea of education as human capital and shadow prices – which we henceforth call the *education approach*. The main difference from previous editions lies in the calculation of human capital: the rate of educational return is used as its shadow price. In line with IWR 2014, health capital is beyond the scope of this method, primarily because it would swamp other capital assets. Additionally, conventional TFP values are used for IW adjusted. Our results are based on both the education approach and the frontier approach in section 3. Because the methodology is in line with the long history of the economics of education, and is consistent with previous editions of the IWR, the reader can compare our results over time. Needless to say, the underlying question from the previous section remains the same: Have nations been maintaining their wealth for the past quarter century? We also use the same data set: 140 countries from 1990 to 2014.

As the methodology in this subsection is inherited from previous reports (IWR 2012 and IWR 2014), it is not surprising that the basic trends in inclusive wealth also continue to hold. In particular, the aggregated accumulation of wealth has been slower than population growth, leading to negative growth rates in IW per capita.

In terms of the total wealth of nations, 133 of the 140 countries (95 percent) enjoyed positive growth rates in IW over the past quarter century (see Fig 1.11a). While it is good news that global aggregate wealth has increased, there are still five countries that experienced a decline in their wealth.

Fig 1.11: Growth in Inclusive Wealth Index, using the education approach

Fig 1.11a : Growth in Inclusive Wealth Index (unadjusted), using the education approach

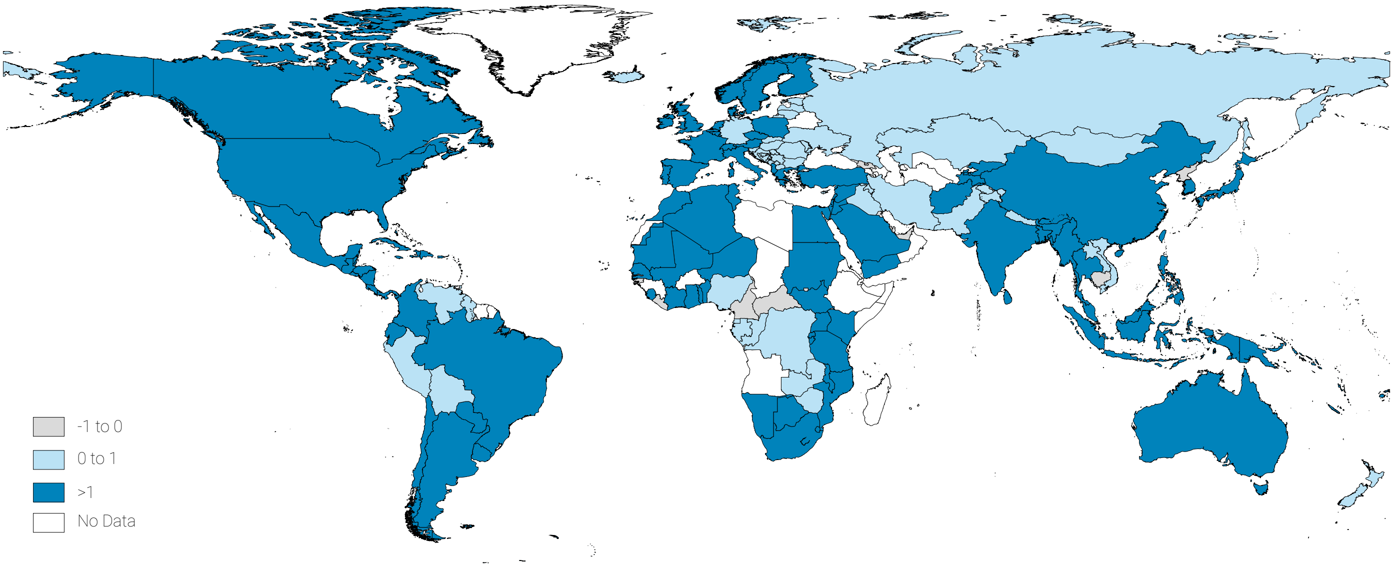


Fig 1.11b: Growth in Inclusive Wealth Index per capita (unadjusted), using the education approach

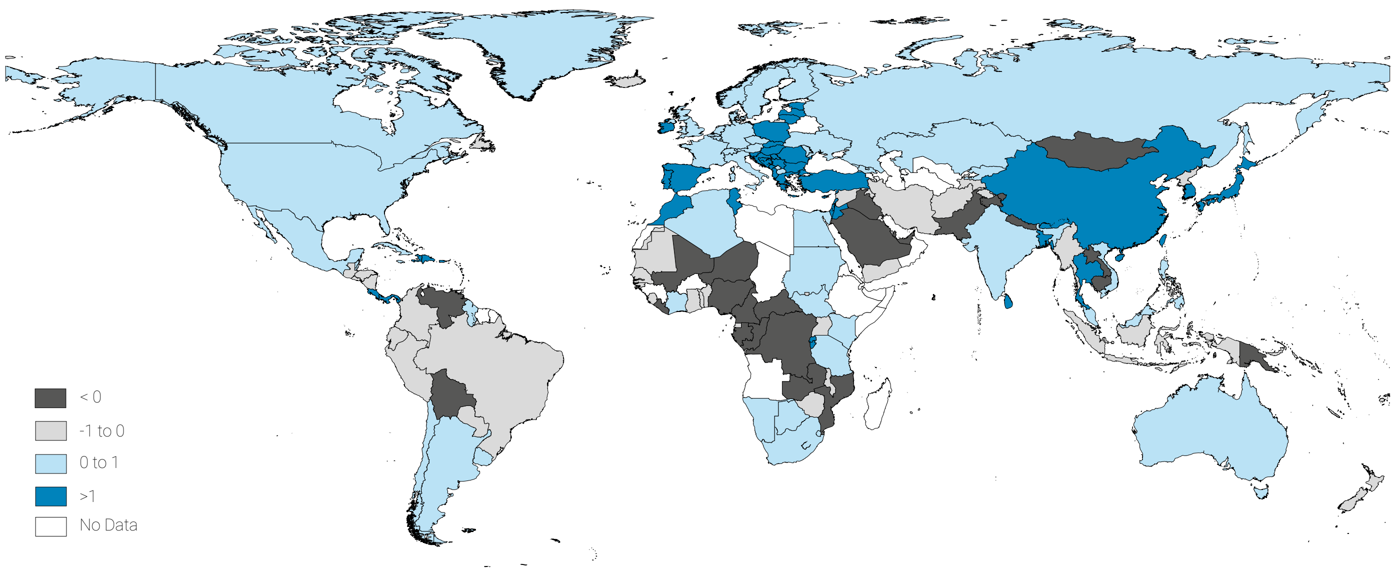
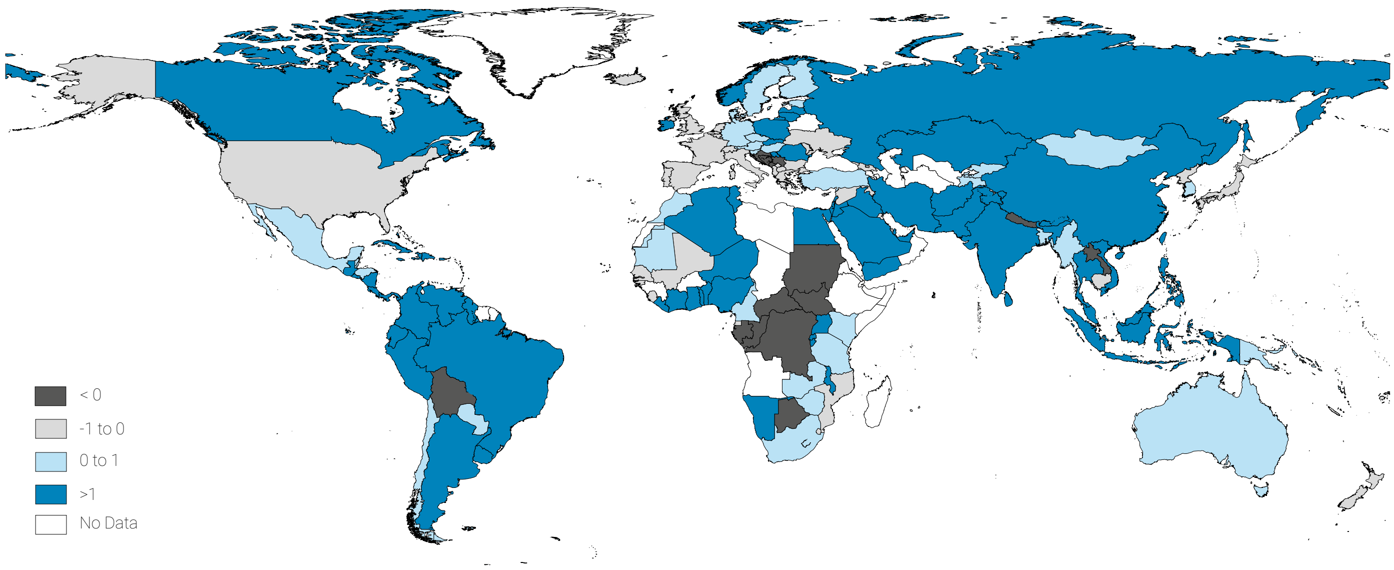


Fig 1.11c: Growth in Inclusive Wealth Index per capita adjusted, using the education approach



If we change the measure from total to per capita, 84 of the 140 countries (60 percent) experienced positive IW per capita (see Fig 1.11b). This decline in performance indicates the impact of the Malthusian effect – the adverse effects of population growth on resources – on sustainability worldwide, particularly in developing countries. Finally, growth in IW per capita with adjustments for TFP, carbon damage and oil capital gains (Fig 1.11c) indicates that 81 of the 140 countries (58 percent) are on a sustainable path.

These figures can be contrasted with the previous results of IWR 2014: for the period 1990-2010, only 128, 85 and 58 of the 140 countries (compared 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 Fig 1.12). Since the sample countries remain unchanged, and the methodology has not changed drastically, this improvement in performance could be down to either the extension of the study period by four years (2011-2014) or to the addition of fishery resources to natural capital.

Fig 1.12: Comparison of numbers of countries with positive IW growth, education approach

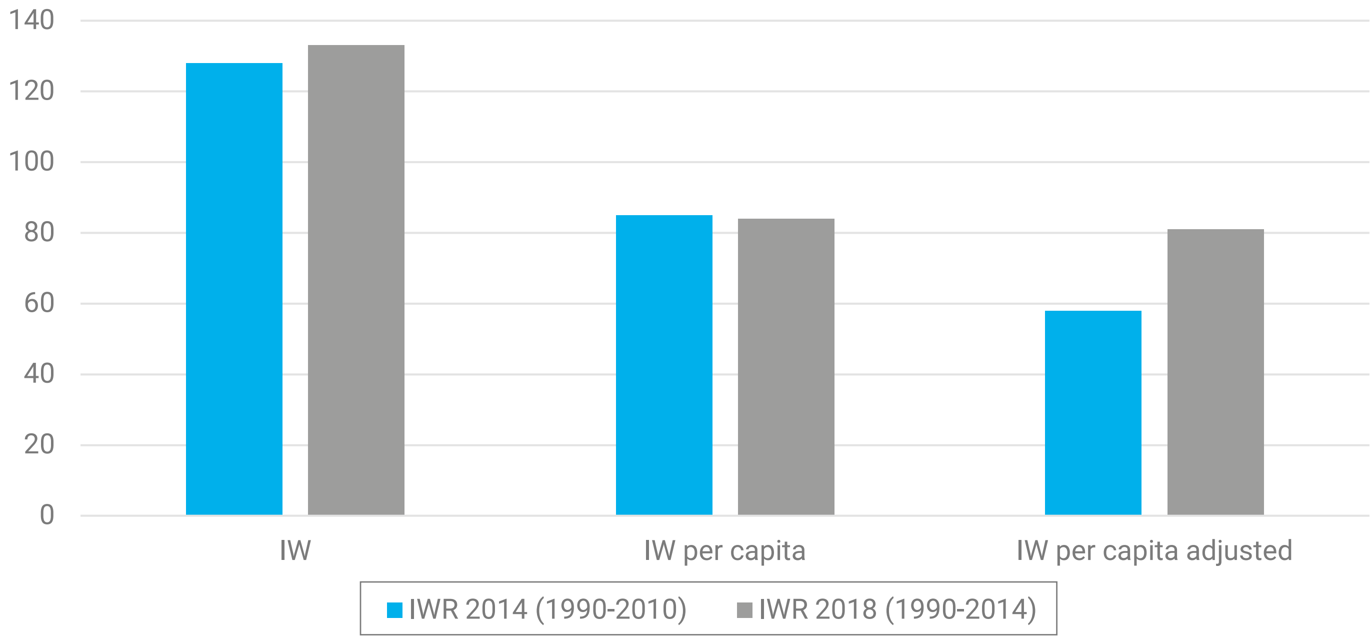
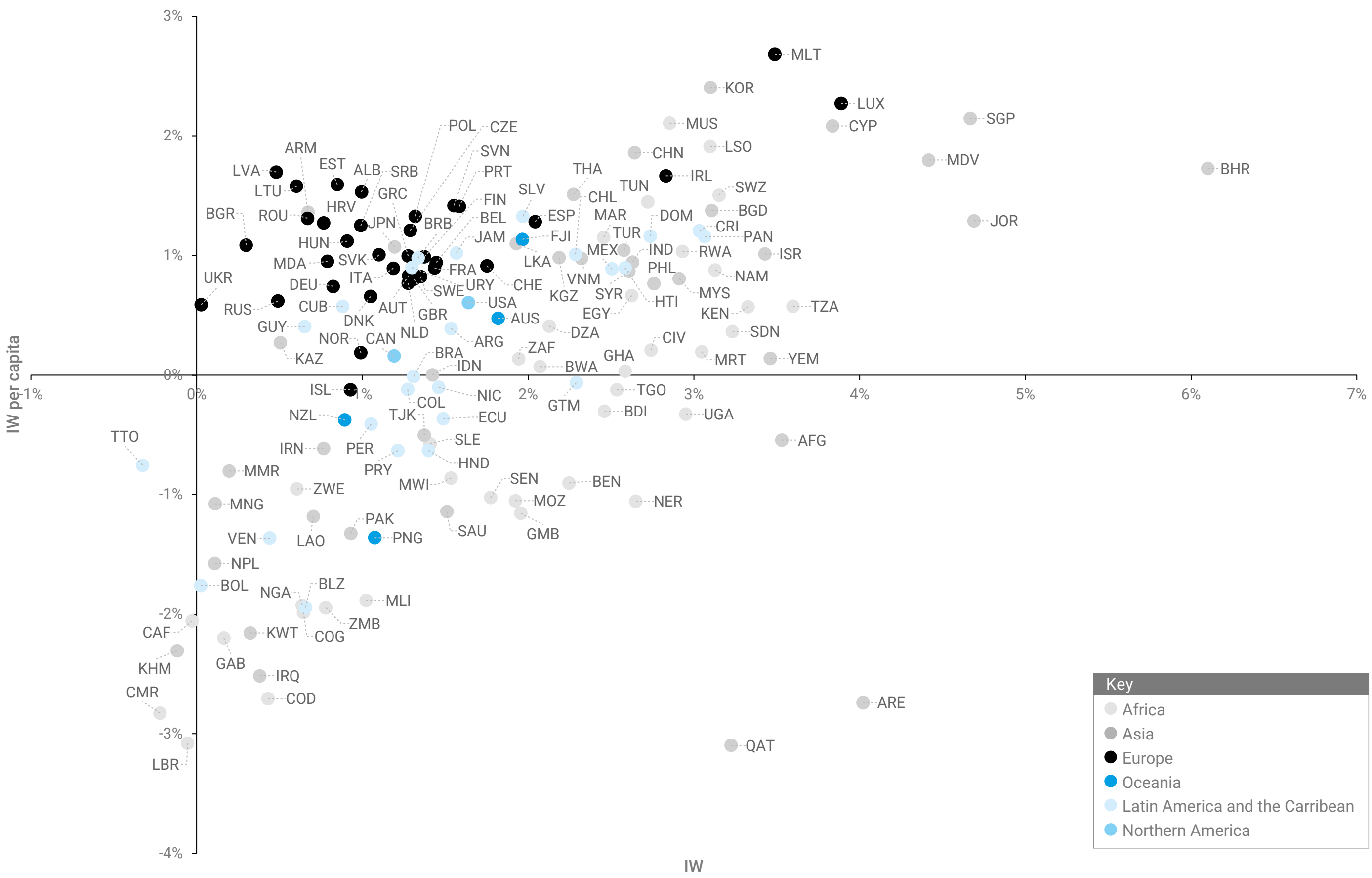


Fig 1.13 shows the relationship between absolute and per capita IW. Overall, we observe a positive relationship between the two: the larger the growth in IW, the larger the growth in IW per capita tends to be. Note also that almost all of the European and North American countries fall into Quadrant I: they have experienced increasing wealth in both absolute and per capita terms. For the other regions, the results are mixed. Bahrain, the United Arab Emirates and Qatar, all of which are sitting on enormous oil and gas capital, lie somewhat as outliers.

The seven countries with negative inclusive wealth growth include four African nations (Cameroon, the Central African Republic, Liberia and Sudan), Trinidad and Tobago, the Republic of Moldova and Cambodia. It is significant that, of these seven countries, only the oil-rich Caribbean nation, Trinidad and Tobago, falls into the high-income category. In absolute terms, Trinidad and Tobago's natural capital has declined by 3.9 percent per annum. It appears that the country has depleted its ample natural capital across the board, from agricultural land to oil and gas, but that the extent to which this has been converted into produced and human capital has not been sufficient to compensate for this loss.

Fig 1.13: Inclusive wealth and inclusive wealth per capita (education approach)



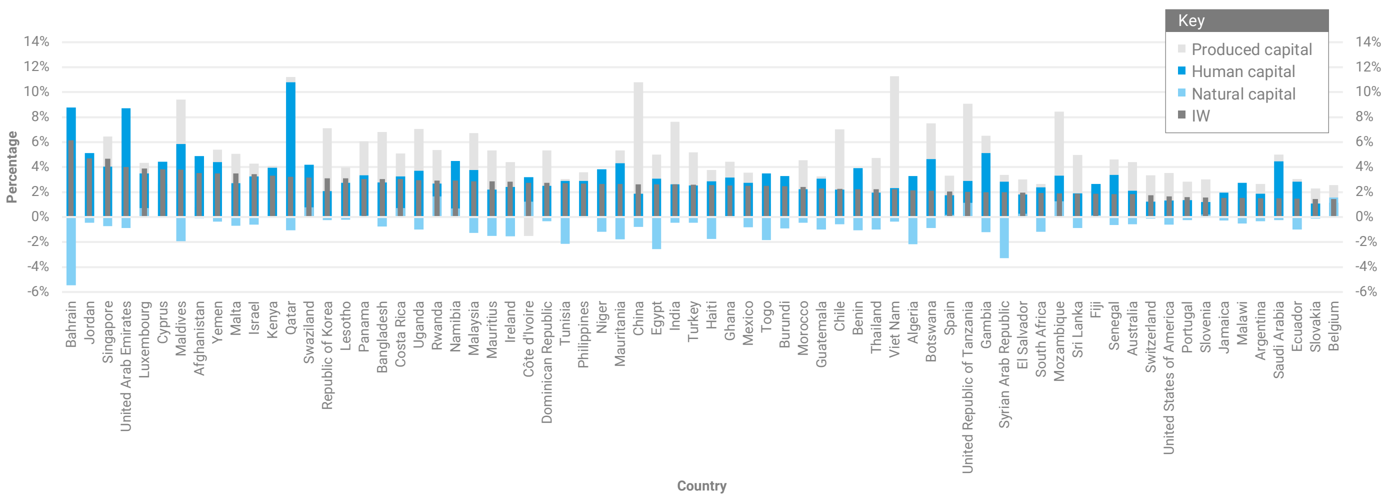
1.4.2. Changes in the composition of wealth

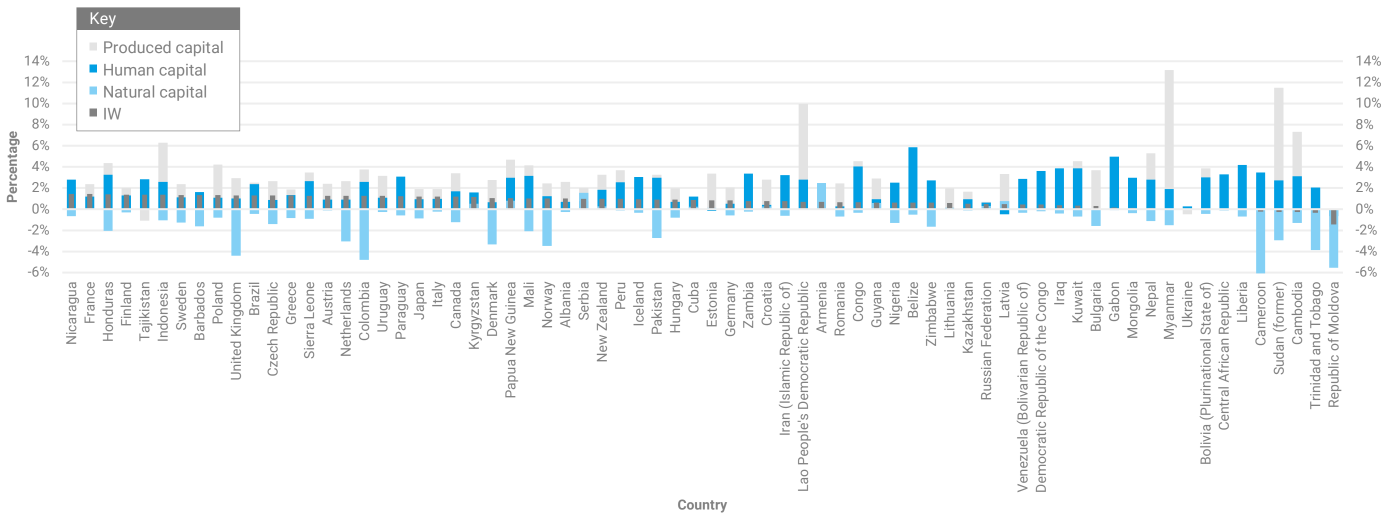
In this subsection, we take a closer look at the breakdown of the contributions of each capital asset group to total inclusive wealth average growth rates. Fig 1.14 shows the breakdown of (unadjusted) inclusive wealth growth into produced, natural and human capital groups. We observe that, even among countries with high inclusive wealth growth rates, the composition of capital assets varies significantly. For example, oil-rich gulf nations (Bahrain, the United Arab Emirates and Qatar) have converted massive amounts of natural capital into other capitals, especially human capital. Other nations, such as Singapore, Tanzania, Bangladesh, the Republic of Korea and the Philippines, have been on a sustainable path, primarily by either growing their produced capital, with very little rundown of their natural resources, or because they are poorly endowed with these resources in the first place.

Turning to unsustainable or barely sustainable countries in Fig 1.14, we note that, despite their sluggish growth in IW, human capital has grown by more than 2 percent (with some exceptions). Their disappointing inclusive wealth growth rates are therefore largely a result of the degradation of natural capital and the slow growth in produced capital. Notable exceptions include several former Soviet republics, such as Ukraine, Russia, Kazakhstan, Lithuania and the Republic of Moldova, where human capital has declined as a result of a decrease in population over the last quarter century. Furthermore, all of these countries have also experienced a decline in natural capital; the Republic of Moldova, in fact, has seen a reduction in all three forms of capital asset.

We note here that, since the growth rates are expressed in geometric terms, the growth rates of each component do not simply add up. Some ASEAN countries, such as Laos, Myanmar and Cambodia, have recently accumulated produced capital but this does not contribute to growth rates in IW for the studied period.

Fig 1.14: Breakdown of growth rates of inclusive wealth into three forms of capital asset before adjustments (education approach)

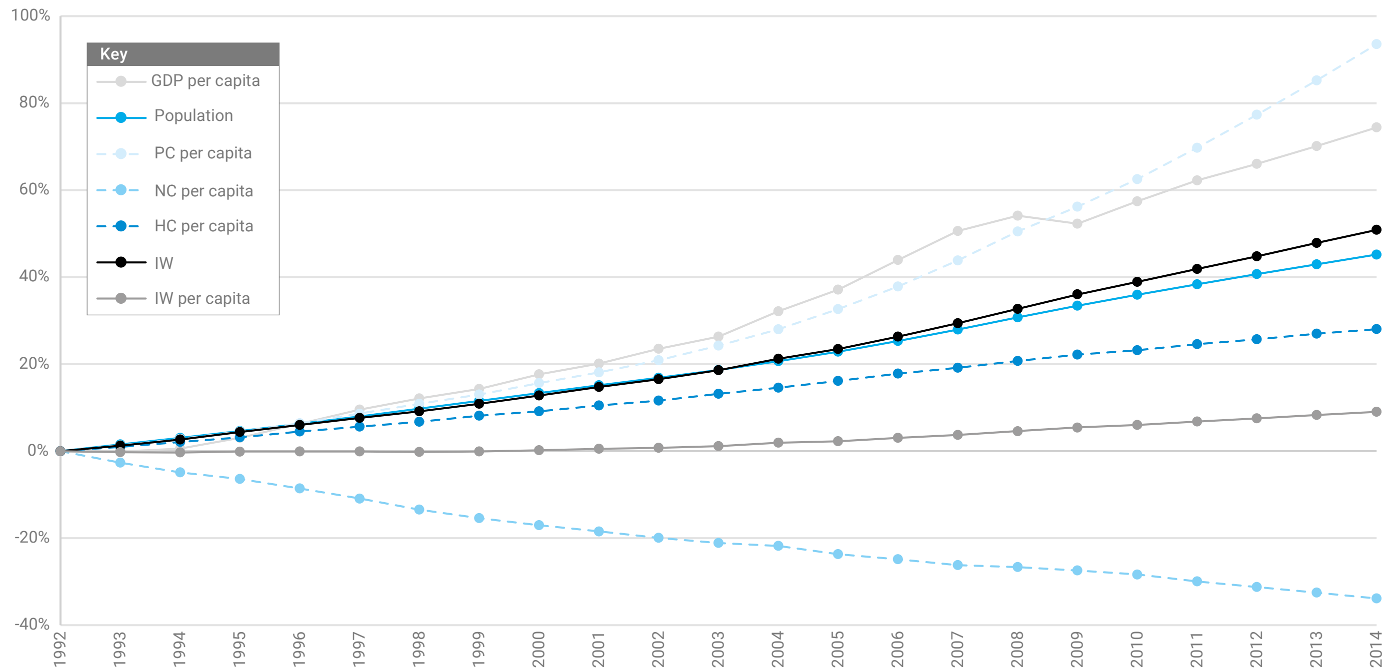




What if we aggregate the data for all the countries? In other words, has the world as a whole been preserving its wealth? Fig 1.15 shows the global change rates of IW and its components on a per capita basis, with 1992 as the reference year.[14] IW per capita has grown slightly, especially over the last decade. It is interesting to note the comparison with IW in absolute terms, which shows a cumulatively large decrease over the same period. Fig 1.15 also demonstrates vividly that natural capital degradation – which amounts to approximately 35 percent in cumulative terms – has been compensated for by investment in human capital and, to a much greater extent, in produced capital.

Another interesting observation from Fig 1.15 is that all of the aggregate global growth in capital assets has been linear, whether positive (produced and human) or negative (natural). In contrast, while GDP growth has been largely positive and linear, the enormous financial crisis caused a notable drop in 2008.

Fig 1.15: Global growth rates of inclusive wealth per capita and its components, relative to 1992 (education approach)



14 The years 1990 and 1991 have been omitted to avoid missing data in some former Soviet republics.

1.4.3. Wealth composition

As previously stated, what matters for the assessment of sustainability is the change in capital assets over the course of years. However, it is also of some interest to examine the composition of capital assets themselves. Fig. 1.16 shows the percentage of the three types of capitals in IW, averaged for the period between 1990 and 2014 (education approach). Fig 1.16a suggests that produced capital accounts for less than 20 percent of total wealth in many countries. It is relatively more important in some developed nations, such as the USA, the EU countries, the Republic of Korea and Japan. In contrast, the share of produced capital is alarmingly low in some developing countries; it accounted for less than 5 percent in some sub-Saharan African countries in 2014. It is difficult to draw normative implications only from this percentage, but history suggests that investing in produced capital would help some poor countries to take off.

Fig 1.16b shows the annual average share of human capital for 1990-2014. It demonstrates that human capital accounts for the lion's share of wealth in many countries. There are, however, several exceptions in the less developed world. As of 2014, human capital made up less than 20 percent of IW in Belize, Bolivia, Guyana, the Central African Republic, Laos, Liberia, Mongolia, Papua New Guinea and Tanzania.

Finally, Fig 1.16c represents the share of natural capital in IW. In contrast to other forms of capital, the share of natural capital largely depends on initial endowments, so it is often very small, both in low-income and high-income countries. For example, natural capital accounts for less than 5 percent of IW in both Belgium and Bangladesh. It is also worthwhile mentioning that some countries that were rich in natural capital are running down their reserves: in Bahrain and the United Kingdom, less than 1 percent of wealth was in the form of natural capital as of 2014, suggesting that they may have depleted their oil capital over the last few decades.

Fig 1.16: Percentages of produced, human and natural capital in total inclusive wealth, average for 1990–2014, education approach

Fig 1.16a: Percentage of produced capital in total inclusive wealth

Fig 1.16b: Percentage of human capital in total inclusive wealth

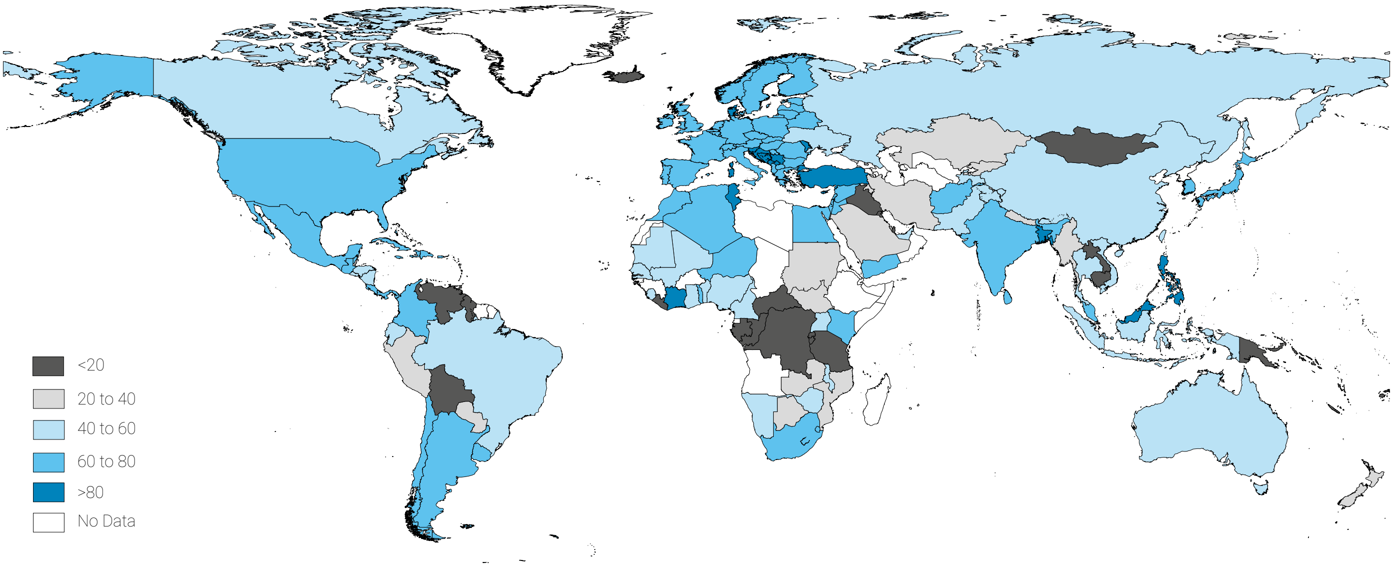
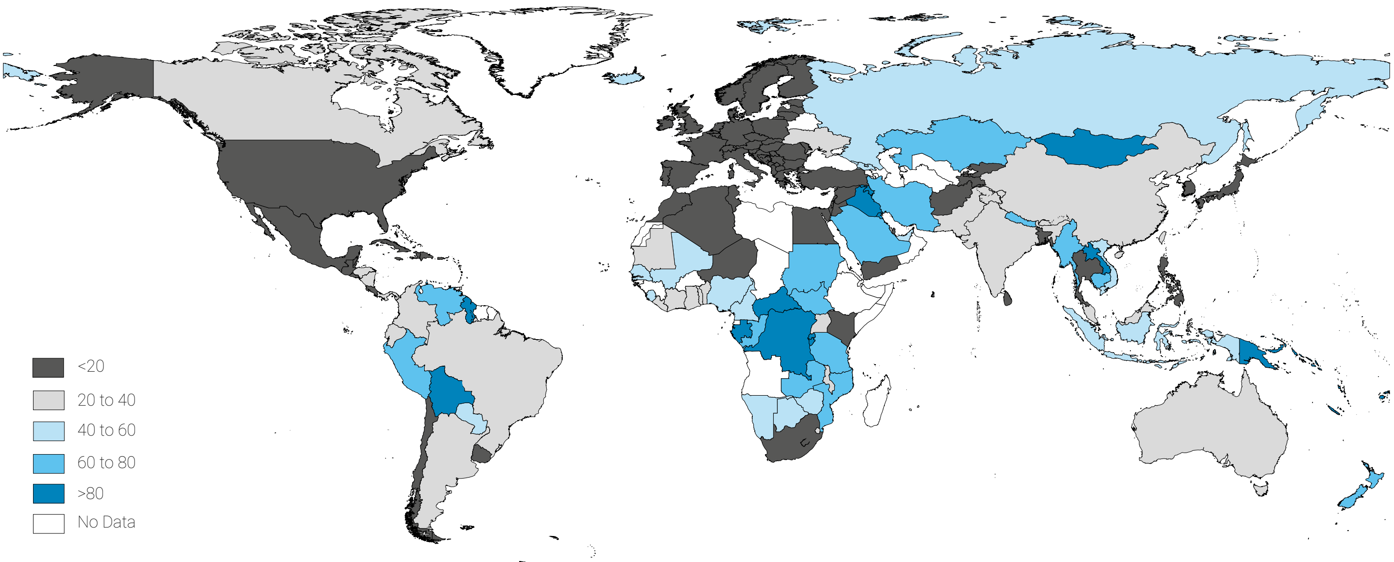


Fig 1.16c: Percentage of natural capital in total inclusive wealth



What about the composition of wealth across the whole world? Fig 1.17a shows that, on average, human capital is responsible for more than half of IW, followed by natural capital, which makes up just over a quarter of total wealth. Produced capital accounts for the smallest share: less than one fifth of total wealth worldwide. Note, however, that this figure is aggregated both over time and worldwide. The right-hand panel of Fig 1.17 shows the temporal changes in the composition of capital. It is clear 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 at approximately 20 percent, while the share of human capital continues to account for more than half of total wealth.

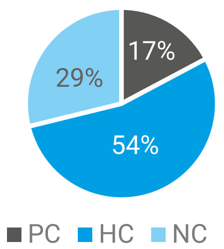
However, a different picture emerges when we use a different approach to aggregating the data. In Fig 1.17b, instead of calculating the average of the shares, we first aggregate each capital for a specific year for the whole world to compute each capital share in the right panel. According to this calculation, produced capital overtook natural capital in the mid-1990s. The pie chart shows the average for the whole period. Natural capital only accounts for 15 percent of total wealth – a somewhat sobering figure in light of the declining trend.

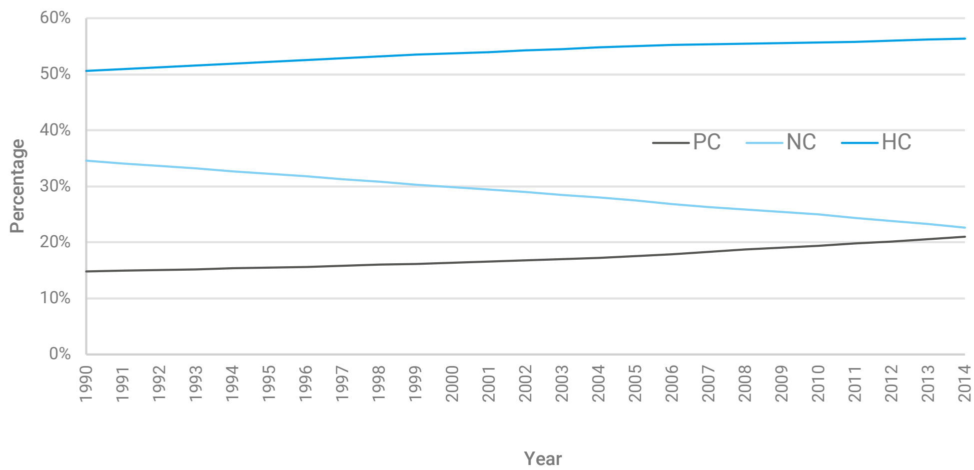
This replacement of natural capital by produced capital should be examined in further detail. The Inclusive Wealth Report (IWR) 2014 found that the share of produced capital tends to be slightly less than 20 percent in many countries, and – interestingly – natural and human capital shares tend to be inversely correlated. This tendency continues to hold for our updated data, as shown in Fig 1.17c. It is tempting to interpret this apparently linear relationship between produced and natural capital as an indication that natural capital is being depleted and converted into human capital. Our approximation suggests that, if one starts from a 'natural state' – with natural capital making up 100 percent of wealth – a 20 percent decrease in natural capital would translate into a 15 percent increase in human capital.

This would be reminiscent of the well-known Hartwick rule, which states that, to maintain future consumption and well-being, rents of depleted natural capital should be invested into other forms of capital (Hartwick 1977; Dixit *et al.* 1980). However, it is important to remember that Fig 1.17c only represents the apparent relationship across countries. In other words, the change in the share of capital assets will differ from country to country according to their historical paths. Moreover, it is important to remember that this correlation does not suggest any causation; it could be that, in theory, investment in natural capital results in a lower share of human capital.

Fig 1.17: Global aggregate wealth composition, mean 1990–2014 and over time, and percentage shares of human and natural capital in total wealth (education approach)

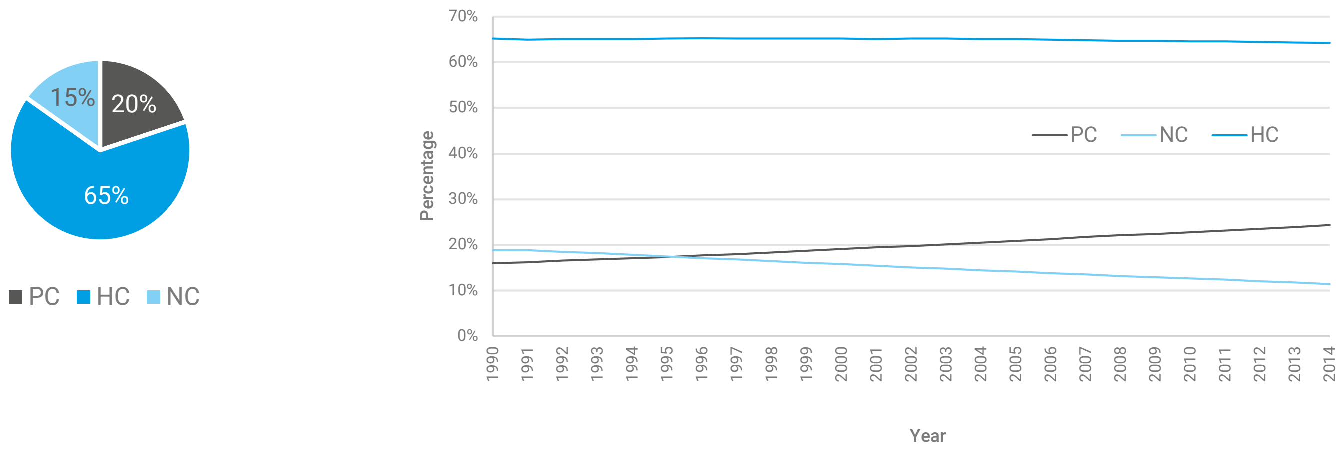
Fig 1.17a: Global aggregate wealth composition, mean 1990–2014 and over time, education approach





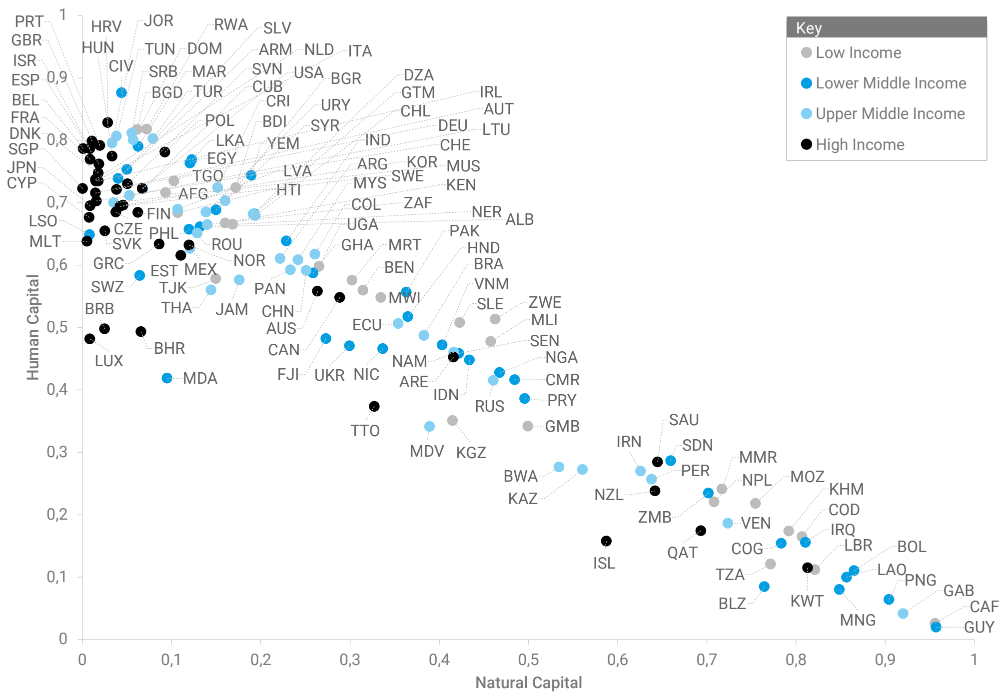
Note: Shares of each capital are computed for each country and year, and then aggregated across countries (the graph on the right). This is then averaged for the whole period, 1990–2014 (the pie chart on the left).

Fig 1.17b: Global aggregate wealth composition, mean 1990–2014 and over time, education approach



Note: Shares of each capital are first aggregated across countries for specific years (the graph on the right). These are then averaged for the whole period, 1990–2014 (pie chart on the left)

Fig 1.17c: Proportion of shares of human capital and natural capital in total wealth, average 1990–2014 (education approach)



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

1.4.4. IWI adjusted

As we demonstrated in the methodology section, an increase in IW should result in an increase in social well-being. Aside from the Malthusian effect – an increase in the scarcity of resources as a result of rapid population growth – there are at least three factors, not accounted for in the conventional forms of capital, that affect social well-being: carbon damage, oil capital gains and TFP. Climate change – driven by increases in carbon emissions – is a global issue. The damage it does to a particular economy does not relate to the level of emissions of carbon dioxide from that economy or the changes in natural capital; it is caused by aggregate global carbon emissions. Oil capital gains boost total wealth through an exogenous increase in the price of natural capital. The economy can also enjoy improved social well-being through an increase in TFP, without any improvement in the quantity of IW. TFP represents technological progress in a broad sense, across the whole of society. In fact, TFP could even be considered as another form of capital asset (Arrow *et al.* 2012).

Fig 1.18 shows a breakdown of the changes in IW per capita following adjustments for the three terms: carbon damage, oil capital gains/losses and TFP.

Not surprisingly, carbon damage as a share of IW affects small countries more because their IW tends to be too small to absorb such exogenous shocks. In this regard, our measure proves useful because we express carbon damage as a share of IW. The annual adjustment for carbon damage does not exceed 1 percent of IW in any of the sample countries. In fact, of the three factors, it contributes the least to the adjustment of IW. Carbon damage has the largest effect on IW in Luxembourg (-0.6 percent), followed by Malta (-0.4 percent), the Maldives (-0.4 percent), Bahrain (-0.4 percent) and Barbados (-0.3 percent). It should be noted, however, that island nations are the most vulnerable to climate change and some are even on the verge of disappearing entirely as a result of rising sea levels; some of these are not included in our sample of 140 countries. In absolute terms, however, carbon damage is relatively large in high-income countries such as Germany, France, the United Kingdom and the United States, among others. In per capita terms, carbon damage exceeds $500 in Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, the United Kingdom, Ireland, Iceland, Italy, Luxembourg, the Netherlands, Norway and Sweden. It is also interesting to note that some countries have become better off due to climate change: Australia, Canada, Israel, New Zealand, Russia and Singapore actually gained as a result of global carbon emissions. In these countries, carbon damage is recorded in positive terms in our accounting.

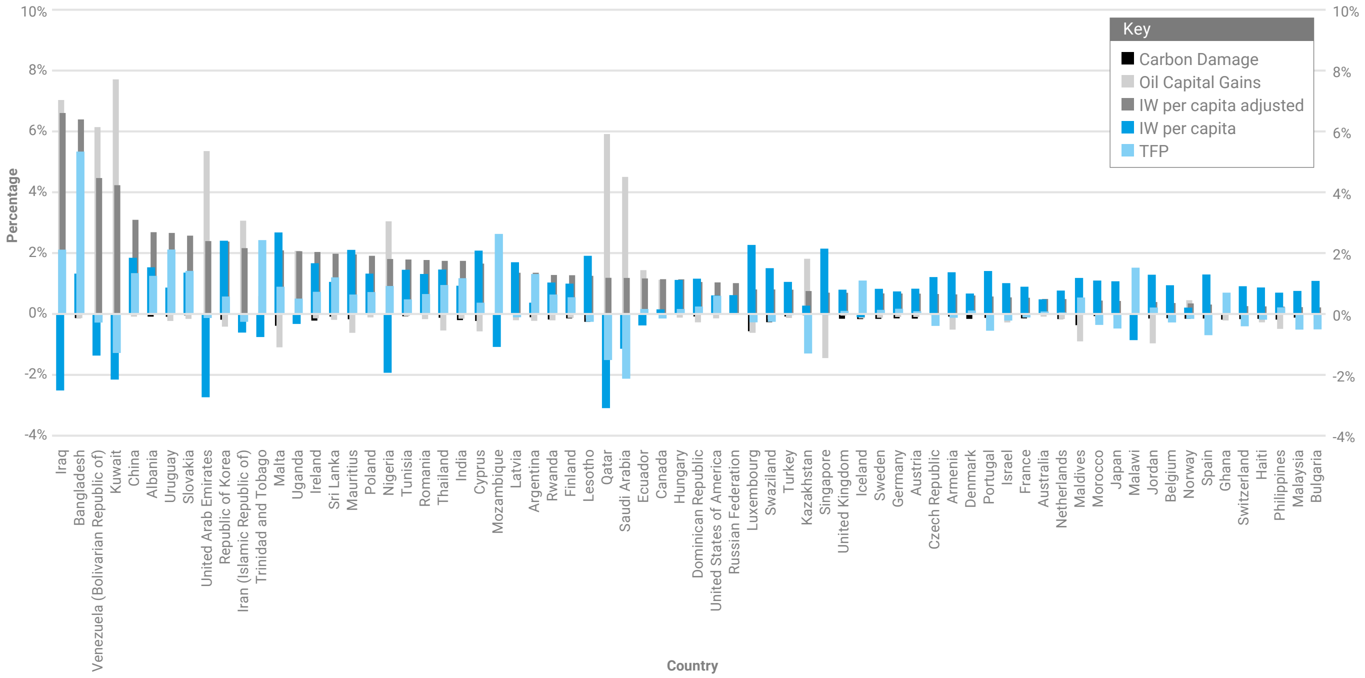
A much larger effect can be observed for oil capital gains and losses. In the current edition, an annual increase of 3 percent in the rental price of oil is assumed, corresponding to the average annual oil price increase during 1990-2014 (BP 2015). This means that even if no oil is withdrawn, oil-producing countries can enjoy a 3 percent growth in social well-being.[15,16] Over the last quarter century, oil capital gains count for more than 1 percent of annual IW in the following countries: Kuwait (7.7 percent), Iraq (7.0 percent), Venezuela (6.1 percent), Qatar (5.9 percent), the United Arab Emirates (5.4 percent), Saudi Arabia (4.5 percent), Iran (3.1 percent), Nigeria (3.0 percent), Uganda (2.1 percent), Kazakhstan (1.8 percent), Ecuador (1.4 percent) and Canada (1.1 percent). They are all countries with enormous reserves of either oil or natural gas, regardless of their income levels. Countries with reserves of unconventional fossil fuels such as shale oil and gas will also gain if oil prices continue to increase. Among those nations with large oil capital gains, the adjusted IW per capita of the United Arab Emirates ends up at a moderate 2.0 percent. In other words, had it extracted its oil wealth more moderately, its IW per capita would have been on a par with, for example, the United Kingdom.

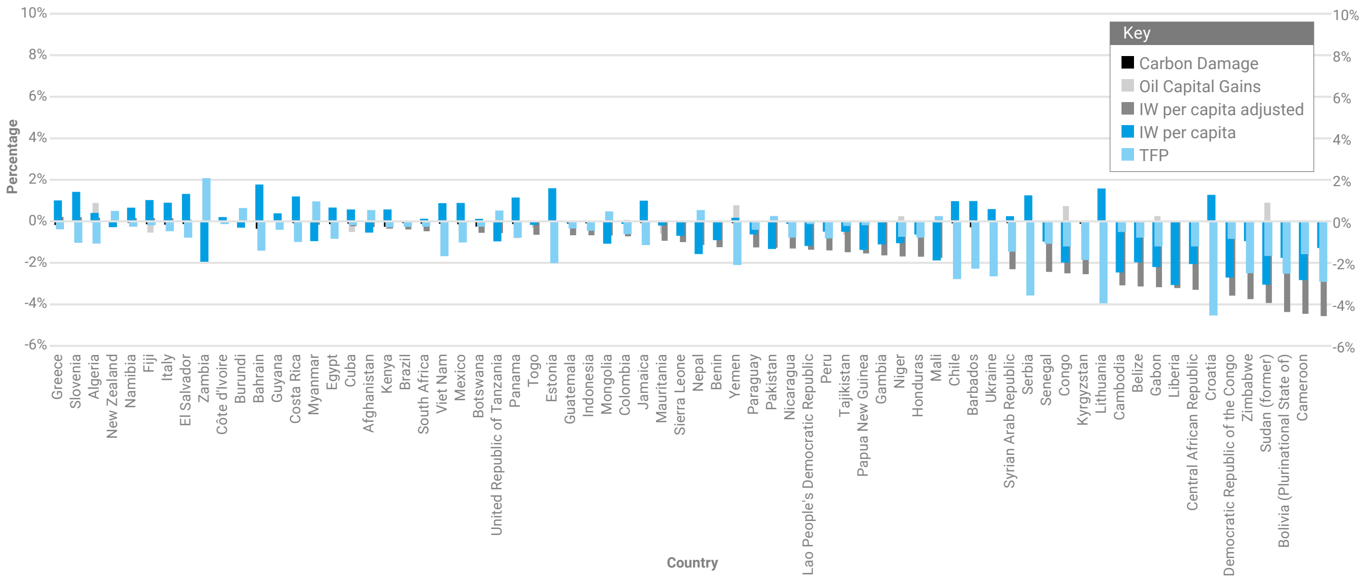
Conversely, there are also ‘losers’ from these exogenous oil price movements. For completeness, we record negative numbers for those that were faced with higher import prices for oil. The majority (113 of 140) of our sample are importing countries with negative oil capital gains. The largest oil capital loss was in Singapore, equivalent to -1.5 percent per annum of its baseline wealth in 1990, followed by Malta (-1.1 percent), Jordan (-1.0 percent), the Maldives (-0.9 percent) and Panama (-0.8 percent), These smaller nations are more affected because of the relative size of their IW and their inability to absorb large oil price shocks. In comparison with oil capital gains, the magnitude of capital losses for individual countries is smaller, reflecting the fact that oil-importing countries are geographically more widespread than exporting ones.

15 In theory, the value of oil natural capital can remain intact if the decrease in the quantity of oil can be compensated for by the increase in oil price when the quantity is fixed.

16 If oil prices increase in the future (which they are likely to), the current list of capital assets could also be adjusted to reflect the 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 prices are too difficult to predict, as recent history demonstrates.

Fig 1.18: Breakdown of the growth in per capita inclusive wealth following the three adjustments (education approach)





Finally, TFP measures residual GDP growth that cannot be explained by the three types of capital assets. As Arrow et al. (2012) demonstrated, in terms of accounting, all we have to do is add the residual TFP growth to the change in inclusive wealth growth. In this section, we take a different tack from the frontier approach in section 3, and instead follow the education approach adopted in IWR 2012. We take the 25-year average of the TFP growth rates reported by the Conference Board (2017).[17] The only shortcoming of this data set is the lack of natural capital, which means that the TFP values might overestimate the true value of technical progress. However, this is not a serious concern because, for the purpose of the sustainability assessment, the final IW per capita adjustments for TFP would be relatively minor (compared to the other adjustments). The development paths of those countries with negative IW per capita and with somewhat optimistic TFP would not be judged as sustainable even if TFP data that took into account the input of natural capital 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 percent. Less than half of the sample (52 of 140) witnessed positive growth in TFP over the last 25 years

17 Of the 140 countries in the sample, 33 countries are missing TFP data for the Conference Board (2017); these are complemented by regional averages.

All things considered, the ultimate IW growth rate, which is adjusted for the three factors, along with population growth, can be calculated: the results are shown in Fig 1.18. Iraq, Venezuela, Kuwait and the United Arab Emirates have all experienced a decline in IW per capita because of the depletion of their oil capital. This demonstrates the importance of oil capital gains as a windfall benefit, particularly in terms of sustainable development. Bangladesh, China, Albania, Uruguay, Slovakia and the Republic of Korea experienced a moderate accumulation in IW and TFP.

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

1.4.5. Comparison with GDP and HDI

In this subsection, we compare our results, based on conventional calculations, with the past performances of other well-known indices. GDP per capita is the most popular index to date for monitoring the progress of nations. Since its launch in the early 1990s, the HDI has also been widely cited as an index for tracking the development of nations. The HDI is a composite index of human capital (health and education) and income levels (GDP). Happiness or, more generally, subjective well-being, has gained attention recently, shedding light on different aspects of social well-being – as opposed to our determinant-based indicator.

Finally, we compare our results with the World Bank's 'genuine savings' measure – the most similar to our index – which tracks formally adjusted net savings (and dissavings) in produced, human and natural capital. For our comparison, we use IWI per capita both before and after adjustments because they differ greatly.

1.4.5.1. GDP per capita

GDP has often been criticized for failing to represent the sustainability of social well-being. GDP growth can differ from that of IWI per capita, as shown in Fig 1.19a and b. Countries in Quadrant I, which make up the majority, have experienced both positive GDP and IWI in per capita terms. This finding is not surprising since portions of GDP are directed towards investment in capital assets. More importantly, many countries still fall into Quadrant II, with positive growth in GDP per capita but negative growth in IW per capita, both in non-adjusted and adjusted terms. Note, however, that the reverse is not true: positive growth in IW per capita is associated with negative growth in GDP per capita (Quadrant IV) for only five countries before adjustments and two countries with adjustments. This finding shows that it might be sufficient to monitor IW per capita growth, even for the purpose of tracking GDP growth.

There is a very weak correlation between growth in GDP per capita and IW per capita before adjustment, but there is a weak but positive correlation after adjusting for all of the income groups. The latter finding is not surprising since one of the adjustment terms, TFP, measures the unaccounted contribution of capital assets to GDP.

Fig 1.19: Growth rates in IW per capita versus GDP per capita

Fig 1.19a: Growth rates in IW per capita (education approach) versus GDP per capita

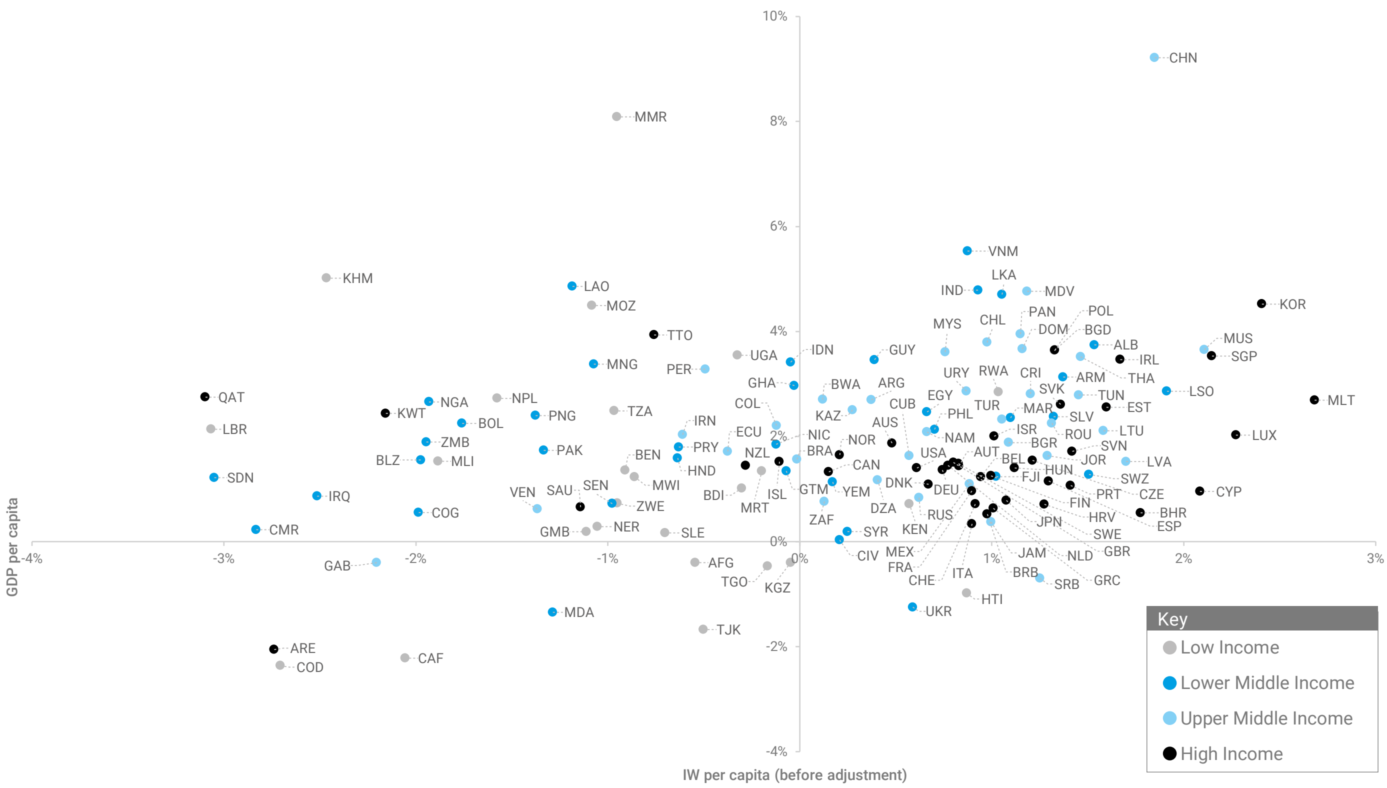
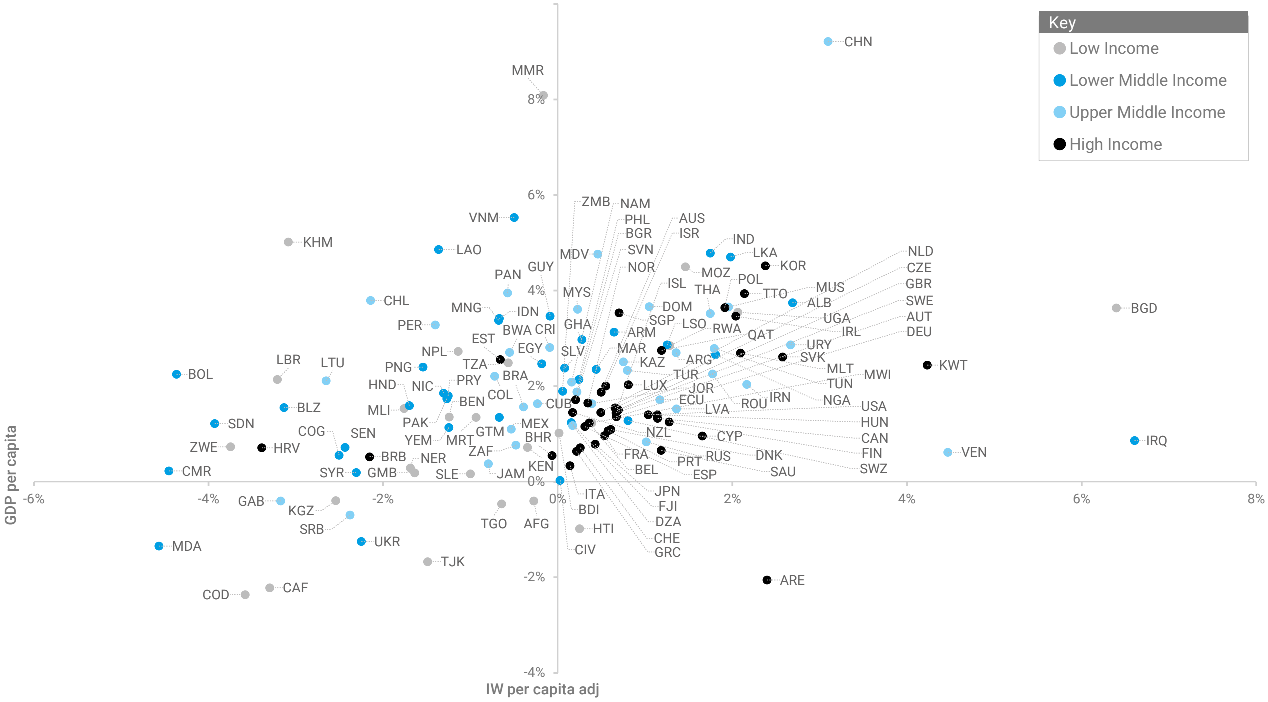


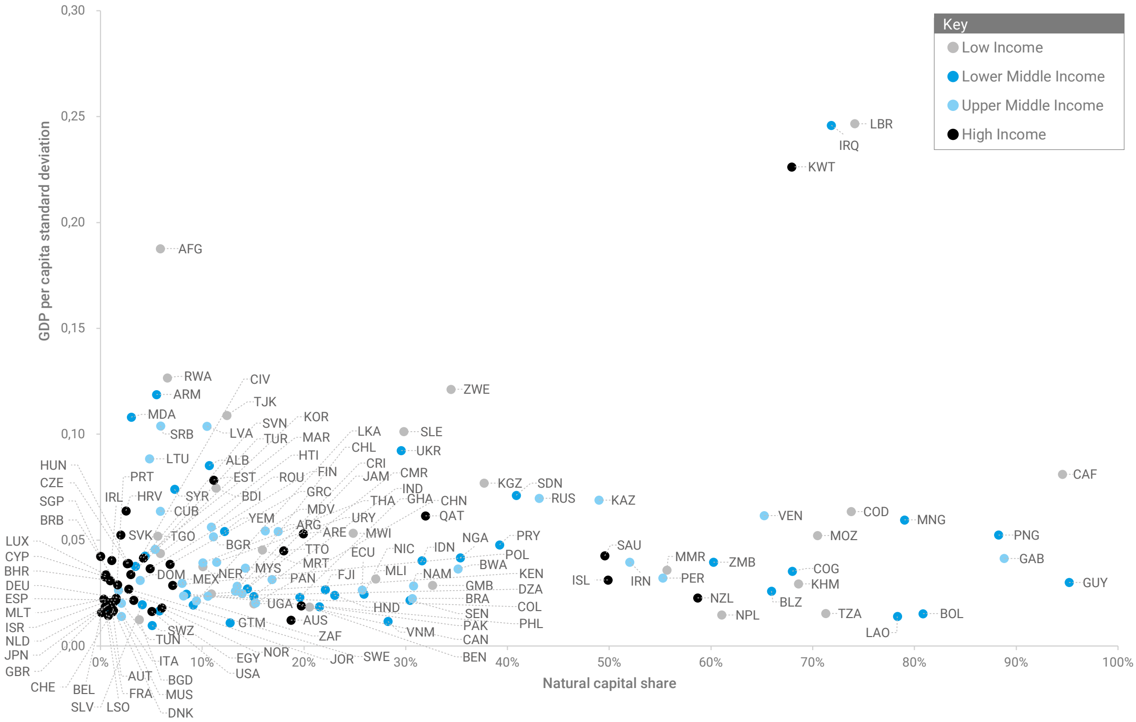
Fig 1.19b: Growth rates in IW per capita adjusted (conventional approach) versus GDP per capita



1.4.5.2. Growth volatility

Some authors have argued that the volatility of resource prices could damage 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 the two compare. Fig 1.20 plots GDP volatility, as measured by the standard deviation of the past 25-year output, against the share of natural capital. In contrast 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. Countries that depend highly on natural capital are not necessarily experiencing volatile output growth, although Iraq, Kuwait and Liberia have seen bumpy growth rates.

Fig 1.20: Natural capital share in 2014 (education approach) versus 25-year average GDP per capita variation (standard deviation)



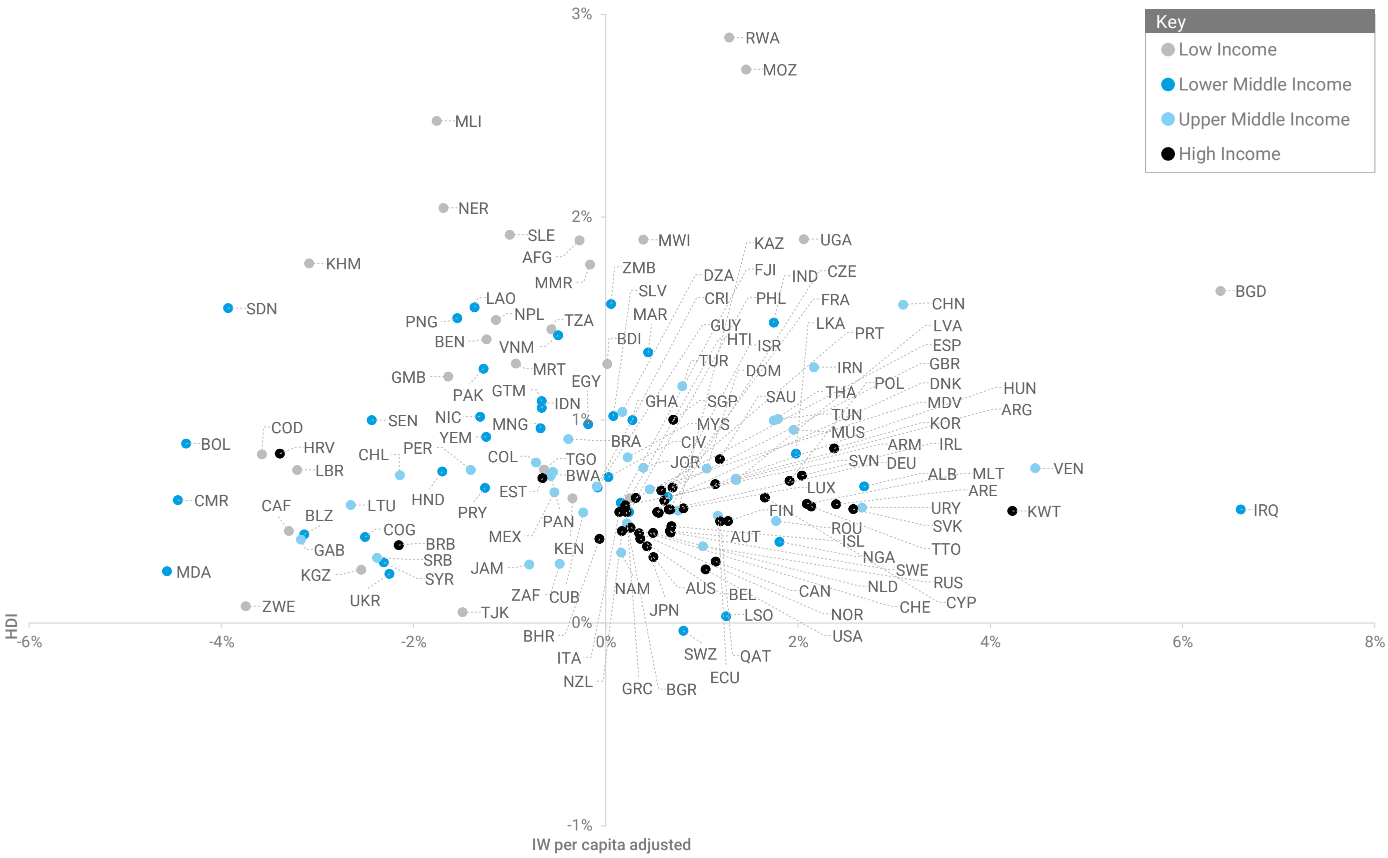
1.4.5.3. Human Development Index (HDI)

What about the correlation between the IWI and another oft-cited index of development, the HDI? Fig 1.21 shows that there is no apparent relationship between the two indices. For lower middle-income countries, it even shows a slightly negative relationship. Therefore, HDI could be sending the wrong message on sustainability. However, if we take a closer look at Fig 1.21b, we can see that, for a limited set of nations, the higher the growth in IWI per capita adjusted, the higher the HDI growth; with a slightly weaker correlation of R^2=0.17 for low-income nations and R^2= 0.21 for upper middle-income countries. No such relationship is evident for high- or lower middle-income nations. Again, there is a slightly better fit for IW per capita adjusted since the economic component of HDI is based on GDP per capita, which includes TFP, which in turn is one of the adjustment terms for IWI.

Fig 1.21: Growth rates in IW per capita (education approach) versus HDI

Fig 1.21a: Growth rates in IW per capita unadjusted (education approach) versus HDI

Fig 1.21b: Growth rates in IW per capita adjusted (education approach) versus HDI



1.4.5.4. Happiness

As we articulated earlier in this chapter, IW addresses the determinants of social well-being. Capital assets comprise the productive base of the economy, which, in turn, become the source of utility for further generations. IW is not intended, therefore, to address the constituents of well-being (Dasgupta 2001). It is not that these constituents should be ignored; rather, they can be used to complement our (determinant-based) approach to give a fuller picture of current and future social well-being.

As depicted in Fig 1.22a, there seems to be almost no correlation between these two aspects of well-being, at least for our studied sample. Note that the vertical axis represents the status of happiness rather than the growth of happiness. For some income categories, a slightly negative relationship can be detected. Although we may be tempted to infer that IW does not buy happiness, this may not necessarily be bad news. As we have argued, IW and happiness are totally different (but complementary) aspects of social well-being.

Fig 1.22: Growth rates in IW per capita (education approach) versus happiness

Fig 1.22a: Growth rates in IW per capita unadjusted (education approach) versus happiness

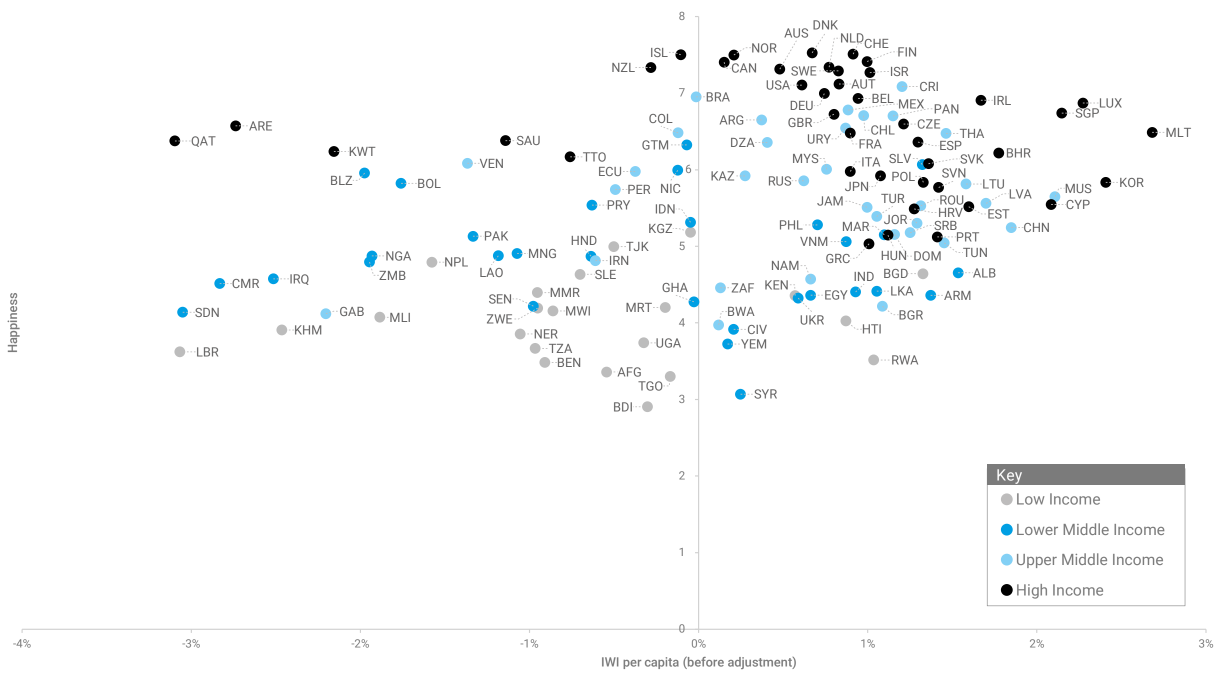
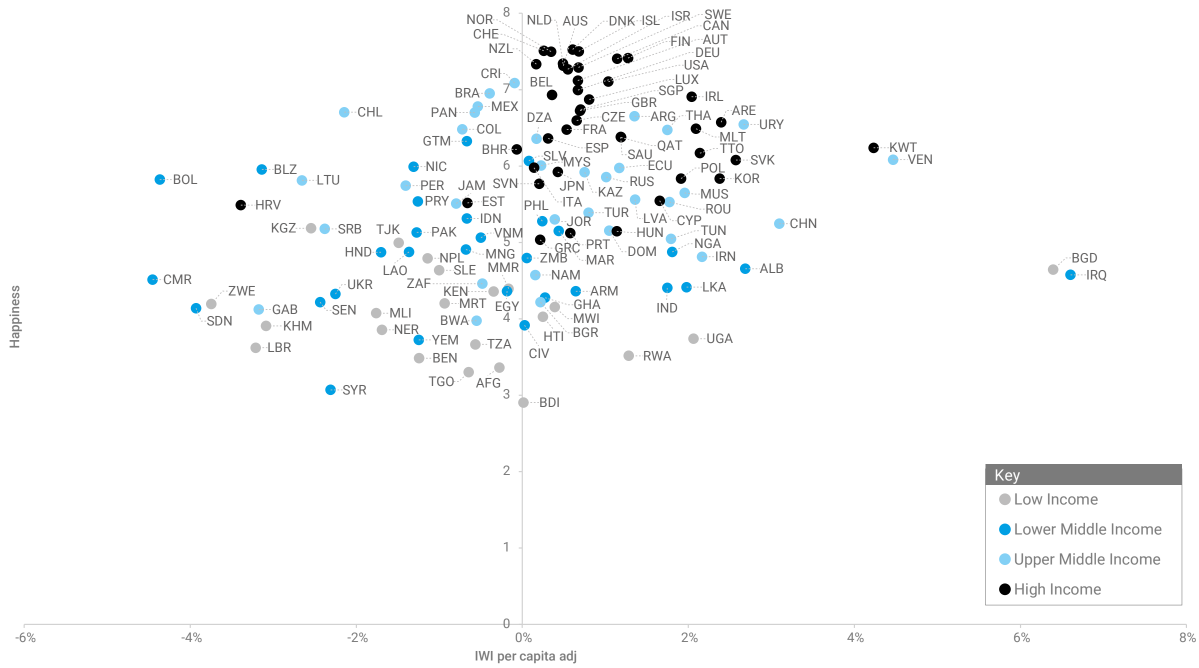


Fig 1.22b: Growth rates in IW per capita adjusted (education approach) versus happiness



1.4.5.5. Genuine savings

As part of their World Development Indicators database, the World Bank started to compute the genuine savings of nations as early as 1999. This composite index is similar to our IWI because they both measure the changes in produced, human and natural capital. However, we differ from the World Bank in many important details. Most notably, the World Bank does not compute annual capital assets per se; it accounts for the change in capital assets. For example, the change in produced capital corresponds to net national savings (NNS). Human capital is recorded as the change in inputs (i.e., education expenditure) instead of outputs (i.e., return on education).

For natural capital, the World Bank analyses fossil fuels, minerals, forests and carbon damage, but not agricultural land and fisheries. Additionally, its notion of intangible capital is based on the residual of the net present value of consumption, which cannot be explained by tangible capital assets. It is not our purpose to discuss in detail the theoretical difference here; for a more in-depth discussion of the comparison, see IWR 2012 (UNU-IHDP and UNEP 2012).[18]

18 The methodology of the World Bank's genuine savings is defined in World Bank (2011).

1.5. Conclusions

Assessing sustainability on the basis of capital stocks seems to be here to stay. However, it should be emphasized that the equivalence between wealth and well-being is the premise from which we all should start. On this premise, changes in well-being should mirror any changes in wealth. Following on from the Inclusive Wealth Report (IWR) 2012 and 2014, we continue our efforts towards identifying a truer measure of the 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 any significance for welfare. Nonetheless, a description of wealth does provide some interesting insights.

In the current edition of the IWR, we show the inclusive wealth of nations, which consists of produced, human and natural capital. This is based on a non-parametric method, which we call the frontier approach. In this approach, shadow prices are determined so that GDP is the output and the three capitals are inputs. According to our results, 135, 89 and 96 of the 140 countries saw increases (compared to their levels in 1990) in IW, IW per capita and IW per capita adjusted, respectively. The global growth rate was 44 percent, which is an average growth rate of 1.8 percent per annum. However, this rate is slower than the annual average GDP growth rate (3.4 percent) during the same period.

If we look at the breakdown of growth, we find that produced capital increased at an annual average rate of 3.8 percent, while health- and education-induced human capital growth remained at 2.1 percent, and natural capital decreased by 0.7 percent. In short, there has been a notable investment in produced capital; however, health, education and natural capital, in which we see enormous potential for future well-being, either grew modestly or even decreased. On a global scale, the composition of capital is as follows: produced (21 percent), education (26 percent), health (33 percent) and natural (20 percent). It is remarkable that, of the different types of capital, only natural capital decreased in value. One way to interpret this outcome is that produced capital and, to a lesser extent, human capital have been enhanced at the cost of natural capital.

Some readers might want to examine education as human capital using the IWR 2014 approach, in which the shadow price of human capital is based on the rate of return on education, as well as conventional TFP (Arrow *et al.* 2012). We have, therefore, also shown the results of our computations for education as a capital asset, following IWR 2012 and 2014. According to this approach, between 1990 and 2014, 133, 84 and 81 countries experienced increases in IW in absolute terms, IW per capita and IW per capita adjusted, respectively. Since the number of countries and the methodology are comparable to previous editions of the IWR, we can compare our results with earlier reports: overall, the numbers have improved from 128, 85 and 58, reported in IWR 2014 (for the studied period 1990-2010). Because, for practical reasons, we do not include health capital in the education approach, the frontier and education approaches are not directly comparable because many variables would be double counted. With this caveat in mind, the averages of the shares of capital assets (which is further averaged for the 25-year period) are as follows: produced (17 percent), human (54 percent) and natural (29 percent), with little change from IWR 2014. However, using a different approach to aggregation, the averages are: produced (20 percent), human (65 percent) and natural (15 percent). The latter is an alarmingly low number, highlighting the rising scarcity of natural resources.

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

Completing the list of capital assets. In the construction of our index, we are asked to account for many capital assets, provided that they affect intertemporal well-being and do not overlap with existing capital assets. Otherwise, the very premise of an equivalent relationship between wealth and well-being would collapse.[19] 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 the tricky relationship between flow and stock variables.[20] In addition, natural resilience could also be added as another essential form of capital, at least conceptually (Mäler and Li 2010) and (in practice) locally (Walker *et al.* 2009). Accounting for resilience in a non-local manner would be difficult, if not impossible.

Institutions and social capital are even more challenging, partly because of their intangibility, and partly because, by their very nature, they enable other capital assets to function and yield well-being (Dasgupta 2015). Therefore, we should resist the temptation to add, for example, social capital as another capital asset in an ad hoc manner, such as the valuation of social capital through revealed preference. A more promising method would be to account for social capital in a two-stage set-up, in which we can examine how social capital raises the shadow prices of other capital assets.

Shadow prices. Even in imperfect economies, the relative weight of capital assets can be formalized as their marginal contribution to social well-being, given a range of economic growth rates in future scenarios (Arrow *et al.* 2012), as we demonstrated in section 2. The current volume of the IWR shows the results of the non-parametric frontier analysis used to compute the shadow prices of human capital. This capital comes with

19 If our list of capital assets is not complete, wealth could deviate from well-being. On an empirical level, there have been studies to test genuine savings and consumption changes (Ferreira et al. 2008; Greaseley et al. 2014), and we recommend similar studies be conducted for inclusive wealth as well.

20 Fenichel *et al.* (2016) attempted to account for local groundwater in an imperfect economy.

its costs: compared to the education approach to human capital shadow prices, GDP is used as the output, corresponding to the three capitals.[21] IW accounting for assessing sustainability is, by construction, founded on intertemporal well-being, so it would be best if we could use the latter (rather than GDP) as the output. Admittedly, the education approach is also not without its faults: the rate of return on education, as well as value of statistical life (VSL) year, is derived from market transactions and thus can 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 will need to update our shadow prices, if necessary, once scientific evidence reveals the scarcity of the components of natural capital.

Coevolution and interdependence of capital assets. The shadow price of a given capital reflects marginal social value, but it can also be subject to other capital assets. In the language of ecological economists, capital assets co-evolve. Negative externality in health capital is a good example. We have already accounted for carbon damage by greenhouse gases in the adjustment terms, but it might also be a good idea to include local air pollution – in the same way that the World Bank (2016) includes particulate matter in its measurement of 'genuine savings'. Indeed, there is ample evidence that local air pollution, both indoor and outdoor, is hazardous to health and poses a threat to longevity. Local air pollution acts more like a flow variable than a stock, but it could be formalized as a persistent negative natural capital. Even so, care should be taken not to double count health capital: the VSL may already capture air pollution in shorter life years.

To provide another example, it is not clear to which capital urban land is allocated; in many cases, it is implicitly within produced capital. In its analysis of state-by-state wealth accounting, Chapter 5 of UNU-IHDP and UNEP (2012) explicitly treats urban land under produced capital. Improving the amenity value of the environment in cities, therefore, could potentially boost the shadow value of urban land. Conversely, natural capital shadow prices could be affected by produced capital investment. However, this question remains open to discussion, since it would involve consumer surplus, which might not exactly match the shadow value in IW accounting. This consideration brings us back, like it or not, to the matter of shadow prices.

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

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