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The Future of GDP

Editorial

Across the globe, a continuous increase in Gross Domestic Product (GDP) ranks on top of political and regulatory agendas. GDP's power as an indicator of economic health and performance is based on the assumption that it adequately reflects the state of the respective society. Accordingly, central banks set monetary policies based on the gap between actual and potential GDP, and governments validate their decision-making in line with GDP growth. It has been argued for some time, however, that decision-makers ought to reconsider their fixation on GDP, which tends to be imprecise in considering assets and often fails to account for liabilities.

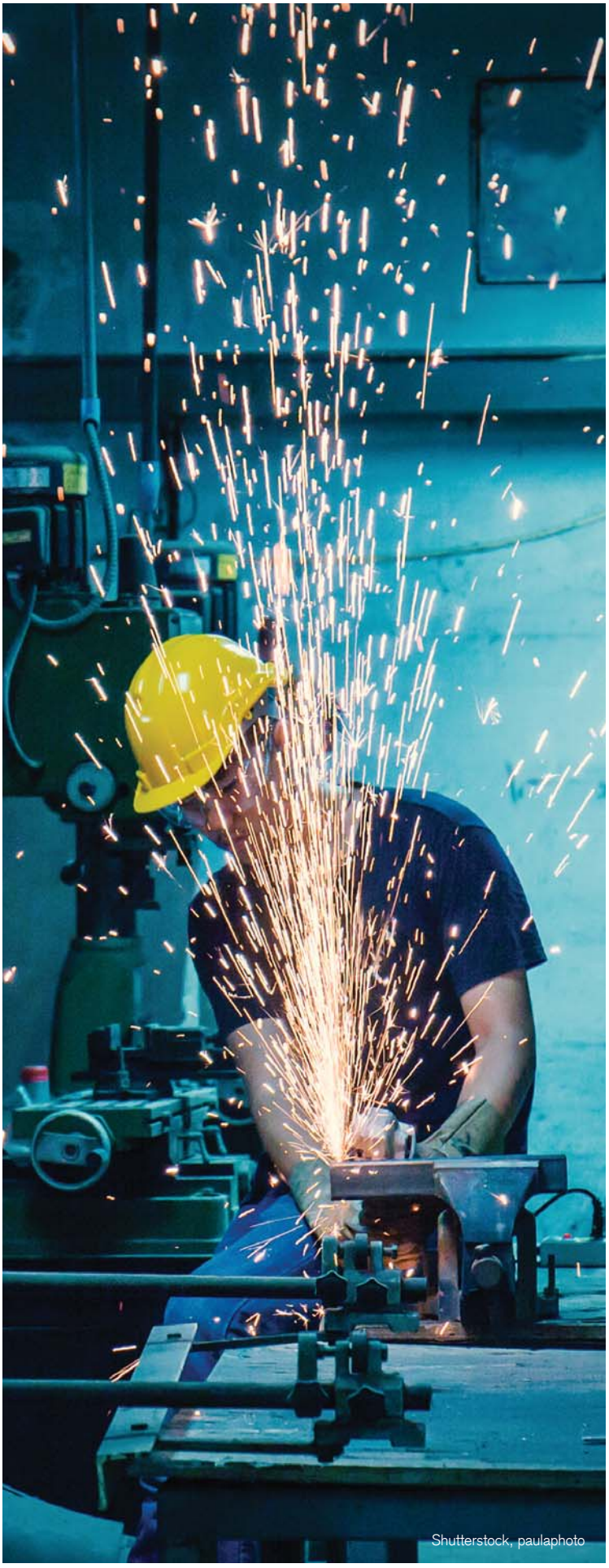
This report, commissioned by the Credit Suisse Research Institute, explores one of the key concerns around measuring progress based on GDP figures, including the inherent lack of consideration for long-term effects of economic growth. Indeed, GDP metrics provide no indication of societies damaging their capital, such as by withholding education from certain groups, or by depleting natural resources for immediate economic benefit. In fact, the definition and methods behind GDP have been questioned since first introduced in the mid-1930s, at the time notably due to the exclusion of government and household activities. Simultaneously, modern economies are increasingly driven by technological innovation, which can have a disruptive impact on statistics. For instance, digital intermediation or user- and peer-driven substitution of marketed products are yet to be reflected in key economic data, such as price indices.

With all its deficiencies, we are yet to find consensus on an internationally acceptable alternative to GDP, although encouraging progress is being made toward a more holistic way of thinking about economic activity. In fact, decision-makers in both private and public sectors now have tools to make highly sophisticated and sustainable choices. On the investor side, the demand for environmental, social and governance data is rising steeply. On the public side, organizations such as the World Bank already consider metrics other than GDP to assess quality of life, including life expectancy at birth or access to education.

As several authors in this report point out, we should focus on a number of issues going forward. First, the weaknesses of GDP metrics continue to be discussed by leading experts, and the relevant stakeholders need to closely follow those debates and take corresponding measures. Second, public and private decision-makers have a multitude of instruments at hand which need to be used to complement GDP figures, as they enable superior assessment of actions and their impact on societies and the environment. Ultimately, in business, we learn not to let the great become the enemy of the good. We have not solved all the challenges, but we have come a long way in reducing many of the distortions of current metrics.

We hope this report furthers the currently ongoing discussions around GDP and wish you an insightful read.

Urs Rohner
Chairman of the Board of Directors
Credit Suisse Group AG



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Introduction to GDP

Gross Domestic Product (GDP) is under attack. This attack is two-pronged. Some feel that GDP is not an appropriate measure to capture the many policy issues facing societies. Others, such as financial market investors, feel that GDP is of little use. These critical views on GDP are justified in the sense that the world we live in is becoming increasingly complex and GDP does not reflect this. The global economy is marked by fault lines such as indebtedness, inequality and low productivity, all of which are undermining the traditional business cycle. In developed economies, other perspectives on welfare – such as happiness or labor market flexibility – demand a different way of examining an economy. Further, the impact of technology, and especially disruptive technology on macroeconomic reporting, is not yet well understood.

Michael O'Sullivan, Chief Investment Officer International Wealth Management at Credit Suisse

The problem with GDP is that it is the measure through which the economics and policy community communicates with the outside world. Most international policy institutions continue to lead their lengthy and detailed policy outlooks with forecasts of GDP. Media institutions also play this game and give far greater emphasis to these GDP forecasts than more arcane analyses of topics like debt. In turn, analysts and economists are then asked to react to new GDP forecasts. To this end, GDP says as much about how the policy community interacts with the civilian world as it does about the analytical models used by economists, and the relevance of their mathematical underpinnings. So, to some extent we cannot do without GDP, but that does not mean that there are not better or alternative approaches to measuring economic growth and well-being.

"It is fair to say that very few investors make investment decisions on the basis of GDP"

In this respect, one element in the GDP debate that deserves more attention is the way in which financial markets use GDP as a source of information. It is fair to say that very few investors make investment decisions on the basis of GDP. Indeed, there is no coincident relationship between stock market returns and GDP (see the Credit Suisse Investment Returns Yearbook 2015). Further, the way in which financial markets digest economic data tells us something about the perceived deficiencies of GDP.

First, while there is an intuitive relationship between asset returns and the business cycle, higher frequency data (such as purchasing manager indices) rather than GDP tend to be used by investors to pinpoint the direction of the economic cycle. GDP tends to be backward-looking, and in many ways tells us little about the output gap. Second, financial markets also highlight a growing appetite for higher frequency and more idiosyncratic data – from app download statistics to micro level hiring trends to oil rig counts, there is a growing number of data items that markets focus on. Some institutions, such as the Atlanta Federal Reserve, have embraced this spirit and produce "nowcast" GDP measures that have gained a following in financial markets.

If the use of the traditional GDP measure is on the wane, its appropriateness is also called into question, and in this report we discuss the main criticisms of GDP as well as possible alternative measures. Here, rather than reiterating the arguments for this, we want to highlight some of the studies and proprietary databases that the Credit Suisse Research Institute (CSRI) has established, and that help to highlight other less traditional perspectives on the world in which we live and work.

One notable category here is wealth. Most people, when confronted by a major spending decision, tend not to reflect on GDP forecasts from the likes of the International Monetary Fund, but rather on their own wealth outlook. The CSRI's Global Wealth Report, now in its eighth edition, measures the wealth of the world's 4.7 billion adults by assessing their financial and non-financial (mostly property) wealth, less debt. It has several uses in the context of the debate on GDP. First of all, we can measure wealth inequality with some accuracy and, in the last edition of the Wealth Report, we highlighted how wealth inequality is at a historic high. Second, the analysis of the wealth pyramid and of wealth trends in the emerging world in particular helps to delineate the rise of the emerging consumer.

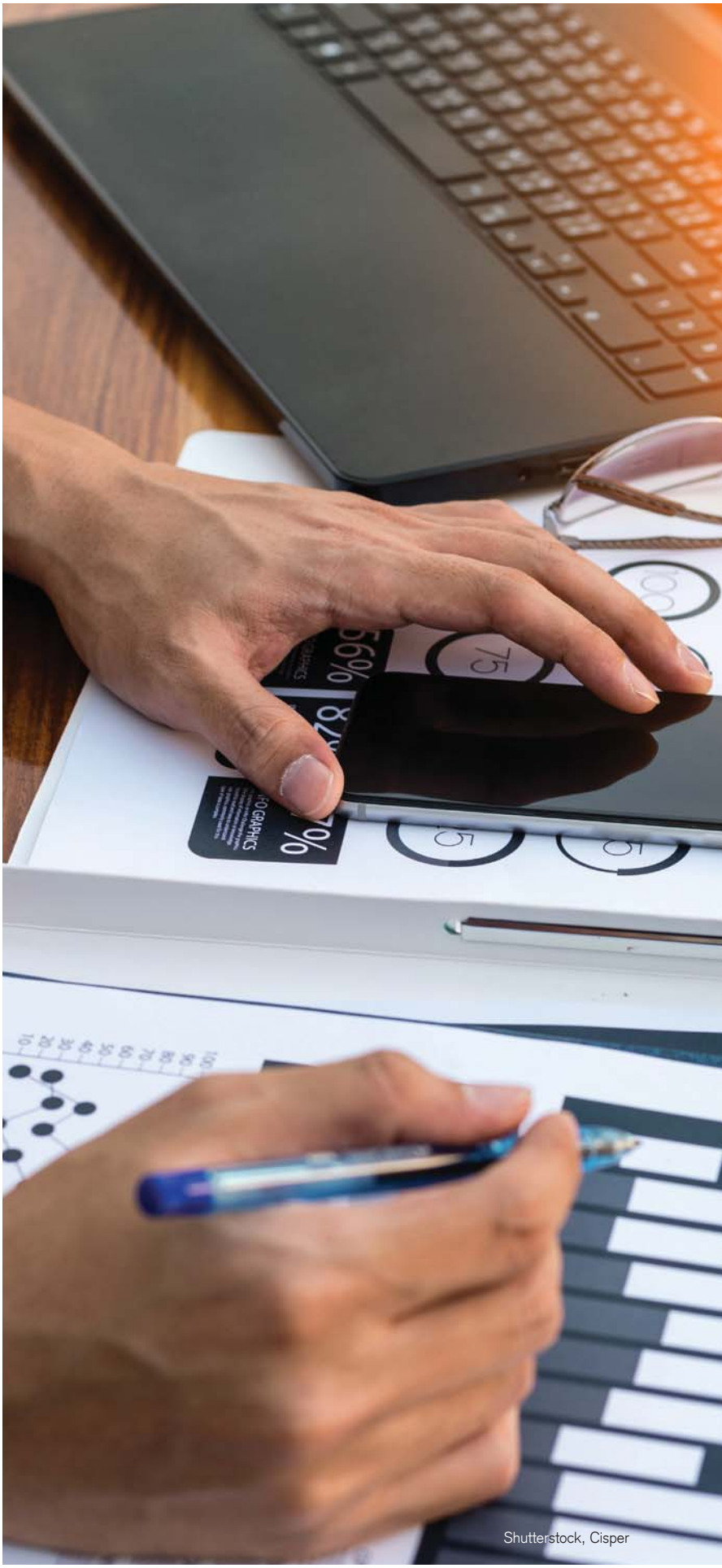
Another related perspective is the CSRI's Emerging Consumer Survey, which examines the aspirations, spending intentions and confidence of consumers throughout the emerging world. The survey is based on detailed interviews with over 14,000 consumers across the eight largest emerging economies. Its role is to provide a granular account of one of the component parts of GDP, consumption, and to track the change in consumption patterns and material aspirations as the level of GDP rises across emerging nations.

"Another important economic cohort is women and, again, the contribution of women to economies is underestimated"

Three other CSRI reports are worth mentioning in the light of the debate on GDP because they shed light on underestimated, and arguably under-researched aspects of the world economy. To take two proprietary CSRI databases first – the CS Family 1000 and the CS Gender 3000. The CS Family 1000 is a database that analyses the world's largest family businesses. Family businesses make up the lion's share of many economies, though receive relatively little analytical attention. This is a pity given that they tend to be more long-term in their investment horizons, tend to invest more and take on less debt than non-family companies and, according to our database, outperform broad equity markets. Another important economic cohort is women and, again, the contribution of women to economies is underestimated. One reason for this is the lack of good quality gender-relevant data. The CS Gender 3000 database makes some inroads here, examining the composition of senior management (by men and women) across 3000 companies, and in particular analyzing the positive contribution that greater female representation makes, for example, in the area of corporate governance.

Finally, in 2014, we undertook a report on the success of small countries. Our aim here was to determine the factors that drove small advanced economies like Ireland, Switzerland, Sweden and Singapore to have consistently high levels of GDP growth. Small open economies are of particular interest because to a large degree they act as the canaries in the coal mine of the world economy in that economic and policy trends tend to show up in them before they do in larger countries. In that respect, keeping an eye on GDP and economic trends in small open economies can be more instructive than a global view.

Our sense is that other perspectives, and the data that supports them, do exist. It is simply a question of bringing these more forcefully into the macroeconomics and policy debate. ■



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Measuring the modern economy with 1940s methods

The past few years have seen great interest in how the economy is measured – not what the statistics say, but rather how they are constructed. This is surprising, perhaps: the technicalities of economic statistics only occasionally come under the spotlight, but the recent interest has been sustained. The reason seems to be a growing gap between what the aggregate statistics say about the economy and the actual experience of many of the people who scrutinize them. One prominent example of this wedge between published statistics and word on the street is the well-known "productivity puzzle."

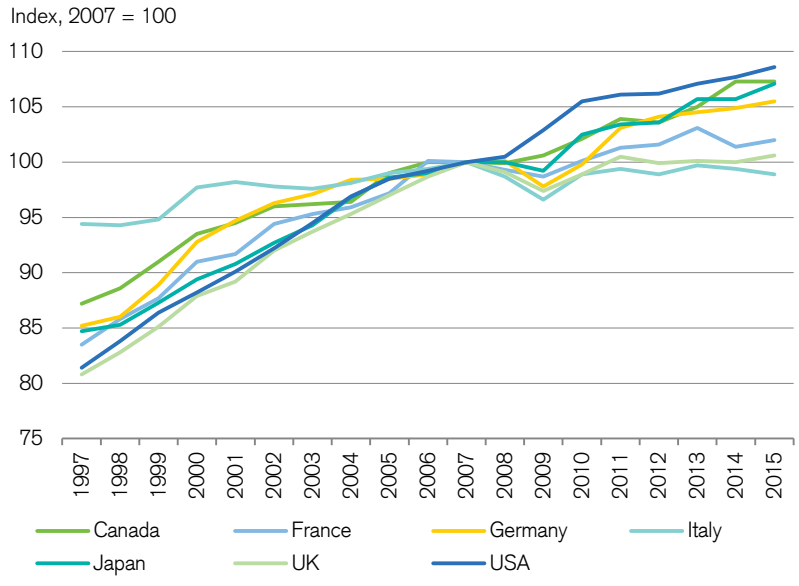
Professor Diane Coyle, University of Cambridge

The productivity puzzle

Productivity growth, measured either as output per worker hour or as total factor productivity accounting for capital input as well, has slowed substantially in the advanced economies since around 2007. The extent of the slowdown varies. In the UK, labor productivity has flat-lined and is now about one fifth lower than it would have been if the earlier trend had continued. In Canada and the USA, the pace of growth has slowed, but not stopped. But all the G7 economies have experienced a slowdown over time.

Figure 1

Constant price GDP per hour worked, G/ countries; 1997–2015



Source: OECD 2018

Why is this a puzzle? After all, there are several contributing factors to weaker productivity, including debt overhang from the financial crisis, demographic change, and a decreasing intensity of competition in key sectors. Another prominent argument, strongly made by Robert Gordon in his book "The Rise and Fall of American Growth," is that the pace of meaningful technological innovation has slowed. He argues that current digital innovations are trivial, and bear no comparison with productivity-improving technologies of the past, including the early stages of computerization.[1]

This argument about technology is debatable, however, and challenged by the tech industries. Telecommunications experts point out that there has been accelerating progress in compression and speed, reflected in exponential increases in data usage. A number of technologies such as electric and autonomous vehicles and associated innovations in batteries and artificial intelligence (AI) point to rapid growth in commercial applications in the near future. There have been pick-ups in automation in some sectors of manufacturing and distribution. Applications of AI in the management of electricity grids and medical diagnostics are being tested, as are new applications of genetic medicine.

This mismatch between statistics and experience due to innovation is one reason the question about measurement techniques has come to prominence. There are others. The conventional approach makes a sharp distinction between businesses and government, which are deemed productive, and households, which are not. The growth of the "gig economy," (characterized by an increasing prevalence of short-term contracts or freelance work as opposed to permanent jobs) is eroding that boundary. The failure of conventional economic statistics to reflect environmental externalities and resource depletion is a long-standing critique, but one that has growing salience.

1. Robert A Gordon, "The Rise and Fall of American Growth," Princeton University Press, 2016.

The stakes are high because of the importance of the conventional statistics in determining policy. Central banks set monetary policy according to the gap between actual and potential Gross Domestic Product (GDP) – but what if both these sets of statistics are too uncertain to be meaningful? Governments justify politically contentious policies in terms of likely contribution to GDP growth. What if what we think we know about the economy is a chimera?

"Central banks set monetary policy according to the gap between actual and potential GDP – what if both are too uncertain to be meaningful?"

To understand the issues, and consider how the measurement of the economy needs to evolve, it is important to start with why we use the framework in place today, its strengths, and its long-understood shortcomings. This sets the stage for understanding why the shortcomings are increasingly profound and wide-ranging. Statistics are both a lens for observing the economy – etymologically, the way the state sees the world – and an instrument shaping the economy as policymakers, businesses and individuals change their behavior in reaction to the picture they see through that lens. The lens has become so distorting that it is time to think about fundamental change to the statistical framework.

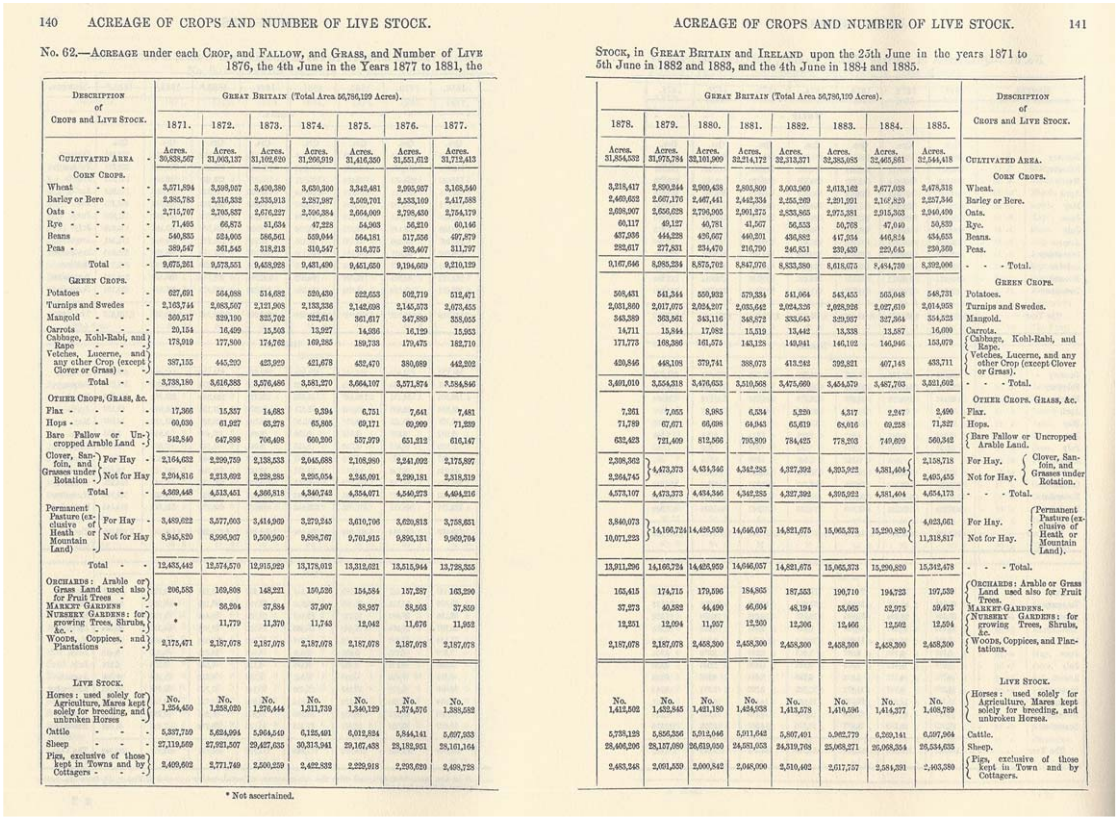
The origins of today's economic statistics

All economic statistics are devised in a particular historical context, and they have changed substantially between different epochs. There are also long lags between change in the structure of the economy and the response in the statistical conventions. For example, in 1885, at the height of the Industrial Revolution, Britain's official annual statistical abstract contained page after page of detailed agricultural statistics and just a handful on steam, mines, cotton, rail and coal, although these leading technological sectors dominated news and conversation, not to mention literature.

Today's framework, the System of National Accounts and associated macroeconomic statistics such as unemployment and consumer price indices, has its origins in the Depression and World War II.[2] The early research by economists such as Simon Kuznets in the USA and Colin Clark in the UK was a response to a political need to understand the scale of the economic catastrophe in the 1930s; there had been vicious trade cycles before, but none since the extension of the franchise to the majority of working men. After the start of the war, the imperative was the need to calculate the scale of the consumption sacrifice needed to enable the diversion of enough resources for war production.

2. A fuller account is available in Diane Coyle, "GDP: A Brief But Affectionate History," Princeton University Press, 2nd edition 2015.

A page from the 1885 Statistical Abstract for the United Kingdom (facsimile edition 1985)



140 ACREAGE OF CROPS AND NUMBER OF LIVE STOCK.

No. 62.—Acreage under each Crop, and Fallow, and Grass, and Number of Live 1876, the 4th June in the Years 1877 to 1881, the

Description of Crops and Live Stock.	Great Britain (Total Area 56,786,129 Acres). 1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Cultivated Area	30,838,567	31,093,137	31,102,620	31,396,919	31,416,260	31,551,512	31,715,413
Corn Crops.							
Wheat	3,371,934	3,398,057	3,406,390	3,630,300	3,342,481	2,995,027	3,168,540
Barley or Bere	2,385,783	2,316,332	2,335,913	2,287,987	2,509,701	2,533,160	2,417,588
Oats	2,715,707	2,705,557	2,676,227	2,596,384	2,654,009	2,708,450	2,754,179
Rye	71,495	66,875	51,634	47,228	54,903	56,210	60,146
Beans	540,335	524,005	506,561	559,044	564,181	517,556	497,879
Peas	389,547	361,545	318,213	310,547	316,375	293,407	311,797
Total	9,675,361	9,573,351	9,458,928	9,431,490	9,461,650	9,104,809	9,210,129
Green Crops.							
Potatoes	627,691	564,088	514,682	620,450	622,653	502,719	512,471
Turnips and Swedes	2,163,744	2,083,567	2,121,908	2,133,336	2,142,698	2,145,573	2,073,453
Mangold	360,517	329,100	325,702	322,614	361,617	347,889	358,655
Carrots	20,154	16,499	15,503	13,927	14,986	16,129	15,953
Cabbage, Kohl-Rabi, and Rape	178,919	177,500	174,762	169,285	189,733	170,475	162,710
Vetches, Lucerne, and any other Crop (except Clover or Grass)	397,155	445,220	425,929	421,678	452,470	380,689	442,202
Total	3,738,180	3,616,383	3,576,486	3,681,270	3,664,157	3,571,474	3,584,846
Other Crops, Grass, &c.							
Flax	17,366	15,537	14,683	9,394	6,751	7,641	7,481
Hops	60,030	61,027	63,278	65,805	69,171	69,999	71,239
Bare Fallow or Uncropped Arable Land	542,849	647,898	706,408	660,206	557,979	651,212	616,147
Clover, Sainfoin, and Grasses under Rotation — For Hay	2,164,632	2,209,759	2,138,533	2,045,688	2,108,980	2,241,692	2,178,897
Clover, Sainfoin, and Grasses under Rotation — Not for Hay	2,204,816	2,213,602	2,238,285	2,295,054	2,245,091	2,200,181	2,318,319
Total	4,369,448	4,423,361	4,376,818	4,340,742	4,354,071	4,540,273	4,494,216
Permanent Pasture (exclusive of Heath or Mountain Land) — For Hay	3,489,622	3,577,603	3,414,909	3,270,545	3,616,796	3,620,813	3,758,631
Permanent Pasture (exclusive of Heath or Mountain Land) — Not for Hay	8,945,820	8,996,907	9,500,960	9,898,767	9,701,915	9,895,131	9,969,704
Total	12,435,442	12,574,570	12,915,929	13,178,912	13,318,621	13,515,944	13,728,335
Orchards: Arable or Grass Land used also for Fruit Trees	206,583	169,808	168,221	150,236	154,584	157,287	163,290
Market Gardens	*	36,394	37,884	37,907	38,927	38,563	37,359
Nursery Gardens: for growing Trees, Shrubs, &c.	*	11,779	11,370	11,743	12,042	11,676	11,952
Woods, Coppices, and Plantations	2,175,471	2,187,078	2,187,078	2,187,078	2,187,078	2,187,078	2,187,078
Live Stock.							
Horses: used solely for Agriculture, Mares kept solely for breeding, and unbroken Horses	No. 1,254,450	No. 1,258,020	No. 1,276,444	No. 1,311,739	No. 1,340,129	No. 1,374,376	No. 1,388,582
Cattle	5,397,710	5,624,094	5,904,849	6,125,491	6,013,834	5,844,141	5,607,933
Sheep	27,119,669	27,921,507	29,427,635	30,313,941	29,167,433	28,182,951	28,161,164
Pigs, exclusive of those kept in Towns and by Cottagers	2,409,602	2,771,749	2,500,259	2,422,332	2,220,918	2,293,620	2,498,728

* Not ascertained.

ACREAGE OF CROPS AND NUMBER OF LIVE STOCK. 141

Stock, in Great Britain and Ireland upon the 25th June in the years 1871 to 5th June in 1882 and 1883, and the 4th June in 1884 and 1885.

Great Britain (Total Area 56,786,129 Acres). 1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	Description of Crops and Live Stock.
Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	
31,854,532	31,975,784	32,101,900	32,214,172	32,312,271	32,385,685	32,460,561	32,544,418	Cultivated Area.
								Corn Crops.
3,218,417	2,890,244	2,960,458	2,893,809	3,003,960	2,613,162	2,677,038	2,476,316	Wheat.
2,460,632	2,567,176	2,467,441	2,442,334	2,453,289	2,291,291	2,256,820	2,257,346	Barley or Bere.
2,698,007	2,656,628	2,706,065	2,661,375	2,633,865	2,675,381	2,915,303	2,940,409	Oats.
60,117	49,127	46,781	41,567	56,533	50,768	47,040	50,839	Rye.
437,936	444,228	426,667	440,201	436,882	447,354	446,854	454,653	Beans.
293,017	277,831	234,470	216,790	246,851	239,439	223,645	230,599	Peas.
9,167,646	8,885,234	8,875,702	8,847,076	8,833,380	8,618,075	8,484,720	8,392,006	- - - Total.
								Green Crops.
508,431	541,344	559,932	579,334	541,064	543,455	565,048	548,731	Potatoes.
2,031,350	2,017,075	2,054,207	2,035,642	2,024,326	2,028,926	2,027,610	2,014,958	Turnips and Swedes.
343,389	363,361	343,116	346,572	333,643	329,937	327,564	354,523	Mangold.
14,711	15,844	17,082	15,519	13,442	13,338	13,887	16,099	Carrots.
171,773	168,386	161,575	143,128	149,941	146,102	146,946	153,679	Cabbage, Kohl-Rabi, and Rape.
439,546	448,108	379,741	388,073	413,562	392,821	407,146	453,711	Vetches, Lucerne, and any other Crop (except Clover or Grass).
3,491,010	3,554,318	3,476,653	3,510,268	3,475,660	3,454,579	3,487,763	3,521,692	- - - Total.
								Other Crops, Grass, &c.
7,261	7,055	8,985	6,534	5,239	4,317	2,847	2,499	Flax.
71,789	67,671	66,098	64,945	65,619	68,016	69,258	71,827	Hops.
632,423	721,409	812,566	795,899	784,425	778,293	749,699	560,342	Bare Fallow or Uncropped Arable Land.
2,208,362	4,473,373	4,434,346	4,342,285	4,327,392	4,305,922	4,281,404	2,158,718	For Hay. — Clover, Sainfoin, and Grasses under Rotation.
2,264,745							2,405,455	Not for Hay. — Clover, Sainfoin, and Grasses under Rotation.
4,573,107	4,473,373	4,434,346	4,342,285	4,327,392	4,305,922	4,281,404	4,654,173	- - - Total.
3,940,073	14,166,724	14,425,959	14,546,057	14,821,675	15,065,373	15,290,820	4,023,061	For Hay. — Permanent Pasture (exclusive of Heath or Mountain Land).
10,071,223							11,318,817	Not for Hay. — Permanent Pasture (exclusive of Heath or Mountain Land).
13,911,296	14,166,724	14,425,959	14,546,057	14,821,675	15,065,373	15,290,820	15,342,878	- - - Total.
165,415	174,715	179,596	184,935	187,553	190,710	194,723	197,539	Orchards: Arable or Grass Land used also for Fruit Trees.
37,373	40,582	44,490	46,004	48,194	53,065	52,975	59,475	Market Gardens.
12,551	12,094	11,937	12,300	12,306	12,466	12,562	12,594	Nursery Gardens: for growing Trees, Shrubs, &c.
2,187,078	2,187,078	2,458,300	2,458,300	2,458,300	2,458,300	2,458,300	2,458,300	Woods, Coppices, and Plantations.
								Live Stock.
No. 1,412,502	No. 1,432,845	No. 1,431,189	No. 1,434,038	No. 1,413,578	No. 1,416,596	No. 1,414,277	No. 1,405,789	Horses: used solely for Agriculture, Mares kept solely for breeding, and unbroken Horses.
5,738,123	5,856,356	5,913,046	5,911,642	5,867,401	5,962,779	6,069,141	6,097,964	Cattle.
28,406,296	28,157,989	26,619,050	24,581,053	24,319,706	25,068,271	26,068,354	26,534,635	Sheep.
2,483,248	2,661,359	2,600,542	2,646,000	2,510,402	2,617,737	2,584,391	2,405,380	Pigs, exclusive of those kept in Town and by Cottagers.

The combination of this urgent need and Keynes's new macroeconomic theory decisively shaped the construction of Gross National (and later Domestic) Product as the sum of consumer spending, investment spending, government spending and net exports – a formula well known to every generation of economics students since.

Although what became today's GDP definition was built on the pre-war work, it differs philosophically in an important way. Kuznets and Clark had aimed to measure economic welfare; Keynes and his US counterparts wanted to measure production and spending. In particular, Kuznets' definition would have deducted government spending on defense as a regrettable necessity not contributing to welfare. This was irrelevant to the wartime measurement need and would have been a public relations goal anyway. This wedge between welfare and output or expenditure is the source of most subsequent critiques of conventional GDP.

After the war, the new definitions were formalized into the current framework and established as an international standard through the United Nations committee that still oversees statistical norms. The British economist Richard Stone, a pupil of Keynes and later a Nobel Prize winner, played a leading role. The advantage of a standard is the ability to compare (albeit with caution) different countries' economies. The disadvantage is that changing the official standard is a slow business that takes up to 20 years.

Traditional critiques

The definition of GDP, and the methods for calculating inflation and real GDP, have been contested since the very start. The treatment of both government activity and household work were hotly debated in the early years, in discussions of the "production boundary," or in other words the line between what is and is not counted in GDP. Simon Kuznets argued that, although some government spending such as education or health spending amounted to collective rather than individual consumption, much of it should be counted as intermediate spending and netted off the GDP total. For example, courts to enforce contracts are an input that firms must have to do business, like raw materials. As GDP counts added value, these costs should all be netted off the total to avoid double counting (a different aggregate, Gross Output, measures all activity including the production of intermediate goods).[3] The distinction proved too complex for statisticians, and did not sit neatly with Keynes's equation.

There was also much debate about "household production," i.e. goods and services produced in the home. The decision was made to count production of goods such as food and clothing as people could choose whether to consume or produce these themselves, or trade them in the market. Services such as cleaning and childcare were excluded, the argument being that the market for these was minimal, and it would be too difficult to collect the statistics.

3. https://www.bea.gov/faq/index.cfm?faq_id=1034.

Feminists naturally objected, as women were the main providers of these services. At any rate, the market for such services is now far larger than the market for homemade food and clothes, although statisticians have little appetite for the data collection that would be needed. This issue may become more significant because of digital technology, however, as discussed below.

"The definition of GDP, and the methods for calculating inflation and real GDP, have been contested since the very start"

The environmental critique was another of the earliest. Although Keynes's concern had been the level of national output and associated employment, the policy target soon became the growth of GDP. The Cold War involved an economic as well as a military arms race, as both the USA and USSR wanted to demonstrate the superior standard of living of their own citizens. Targets for growth were set in the founding charter of the Organisation for Economic Co-operation and Development, the successor to the body administering US Marshall Fund aid. Environmentalists were quick to point out the implications of continual economic growth set in terms of a target for a measure that omitted environmental externalities, such as pollution or greenhouse gas emissions, and took no account of depreciation of the stock of environmental assets, treating natural resources as free.

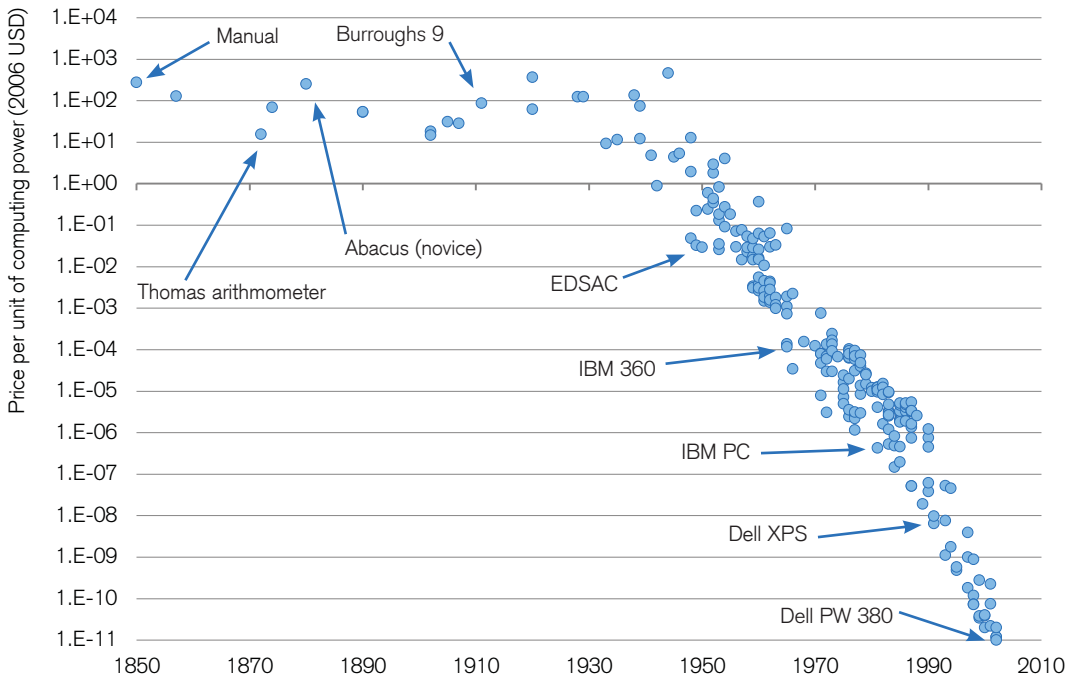
A significant drawback of relying on GDP as a guideline is that it is a flow measure. It measures economic activity in the current time period, valuing it at market prices that by definition omit social costs. There are balance sheets in the System of National Accounts, but they are incomplete – for instance, the contingent liabilities of governments are omitted. So too are the stocks of natural assets, with just a handful of countries starting to try to measure natural capital stocks. For that matter, GDP does not distinguish between a dollar of investment and a dollar of consumption, so it does not provide any guidance at all on the time trade-off between growth rates in different periods.

Such concerns have led to many proposed alternatives to GDP such as the Index of Sustainable Economic Welfare and the Genuine Progress Indicator.[4] However, their strength is also their weakness. In using market prices to value real output, GDP has the democratic strength of reflecting the choices people actually make in

4. See "Measuring Progress? A Review of 'Adjusted' Measures of Economic Welfare in Europe," by Tim Jackson and Nat McBride, CES Working Paper, University of Surrey, 2005. https://www.surrey.ac.uk/ces/files/pdf/1105-WP-Measuring-Progress-final.pdf.

Figure 2

US GDP per capita & GPI per capita, USD 2000, 1950–2004



Source: Nordhaus 2013: Cost per computation per second deflated by price index for GDP in 2006 prices. Log scale

their behavior. All the alternative indices make ad hoc assumptions about how to weight different components together to construct a single index. Devised by environmentalists, these put such a heavy weight on environmental externalities and resource use that they show there has been no economic progress since the 1970s. This is unreasonable if you think about the significant improvements since then in ultimate indicators such as health, longevity, infant mortality, and quality of life for most people in the OECD economies. So how to account for the environment in a rigorous way is a puzzle yet to be solved.

"How to account for the environment in a rigorous way is a puzzle yet to be solved"

The existence of such improvements leads on to another basic shortcoming in GDP, however. That is its inability to measure the economic welfare or well-being benefits of technological innovations. The value people place on a new product or service is almost always far higher than the price they have to pay when it is commercialized and available in the market. GDP is calculated using the market price. To see this, consider the fact that Nathan Mayer Rothschild, thought to be the richest person in the world at the time, died in 1836 of an infected tooth abscess because antibiotics had not been invented. What might he have paid for a dose that would cost 20 dollars today?

There are many examples of new goods creating significant "consumer surplus," as this excess of value over market price is known. Its omission on the positive side explains why the indices described above, subtracting environmental costs, seem so odd. Economists have tried to calculate "true" prices for some significant innovations over long periods. For example, William Nordhaus has constructed indices for lighting and for computation.[5] These calculate the unit costs of physical output such as lumens or computations per second and, not surprisingly, their pace of decline is radically faster than the pace recorded in official GDP price deflators. Statisticians make adjustments now for technology-driven quality changes in some key products such as televisions and computers, calculating prices in terms of underlying physical characteristics such as processing speed, screen resolution and so on. However, during periods of rapid technological change – and changes in a broader range of goods and services building on the technologies – there is bound to be a large innovation factor affecting the official statistics. This is a key question to be addressed at the moment, particularly in light of the productivity puzzle.

Digital disruption of statistics

Digital technologies are manifestations of a "General Purpose Technology," computation power driven by Moore's Law, and resulting in a cluster of information and communication technologies (ICTs). These

5. Nordhaus, W. (2007), "Two Centuries of Productivity Growth in Computing," The Journal of Economic History, 67(1), 128-159. doi:10.1017/S0022050707000058.

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include the internet and web, wireless communication networks, devices from supercomputers to smartphones, AI and robotics. Digital technology has also enabled advances in other fields apart from information and communication technology thanks to cheap and large-scale computational power, such as genetics. General Purpose Technologies (such as printing, or steam and electricity) first have an impact in their specific sectors, but subsequently pervade the whole economy. This can be a process with long and variable lags.

The economic historian Paul David showed that it took 30–50 years from the initial innovations for the productivity effects of electricity to appear because so much complementary investment and organizational or social change was needed.[6] The difficulty in measuring innovation means profound technological changes also have surprisingly little effect on measured GDP. Nicholas Crafts has shown that the impact of steam on measured labor productivity growth in the UK was 0.4% a year at its peak – less than a quarter of the estimated impact of ICTs on US productivity in the mid-1990s, yet nobody would doubt the significant economic and social consequences of the steam revolution.[7]

When digital technologies first became widespread enough to be noticed in the 1980s, the absence of any productivity impact was widely commented on. Robert Solow famously remarked, "You can see the computer age everywhere but in the productivity statistics."[8] This paradox seemed to be resolved by the 1990s, but the acceleration in productivity growth then has evaporated. Yet digital technology is far more pervasive now than it was 20 years ago. A majority of people in many countries are able to be online constantly thanks to broadband and smartphones. Chips are embedded in a growing number of products. E-commerce is expanding. Products such as music and films are dematerializing.

"You can see the computer age everywhere but in the productivity statistics" – Robert Solow

Work patterns are changing substantially, with much more work mediated through digital platforms. Automation is spreading to some routine service sector activities such as legal search, company reporting, and medical diagnosis. Yet – just as official statistics painted a rural picture of a rapidly industrializing economy in 1885 – little of this digital disruption seems to be captured in official statistics now. There are multiple ways digital technology is disrupting the statistics. The table at the end of this article provides a typology attempting to capture these. To start with the production boundary, it is clear that more productive activity is now

6. David, P.A., "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox," American Economic Review, 80 (2), 1990, 355–361.
7. Crafts, N. (2010), "The contribution of new technology to economic growth: Lessons from economic history," Revista De Historia Economica / Journal of Iberian and Latin American Economic History, 28 (3), 409–440. doi:10.1017/S0212610910000157.
8. Robert Solow, New York Review of Books, 12 July 1987.

taking place inside households, but – as alluded to above – is not being counted in official GDP.[9] There are three significant categories:

- Digital intermediation, whereby people no longer visit high street intermediaries such as travel agents, banks or insurance brokers, but interact with alternative online intermediaries. They use their home devices and broadband and some of their own time, but save time compared with the past, have more choice and the ability to customize, and probably pay lower prices. Some of the new intermediaries are based overseas. This has been an extensive substitution of digital for traditional services.
- The "sharing economy" involves the use of household assets such as a room or a car, or human capital skills, to earn income. Participants also provide labor – such as cleaning the room or driving. In principle, this activity should be captured in existing statistics, but has not been sampled. Nor have the lower prices consumers pay for accommodation or taxi rides been included in price indices.
- Home production of digital goods ranges from Wikipedia entries, personal blogs and videos to innovative medical services and open source software and computer services. These will all to some extent have substituted for marketed products, yet the zero price paid for them is not captured in price indices and therefore in real GDP.

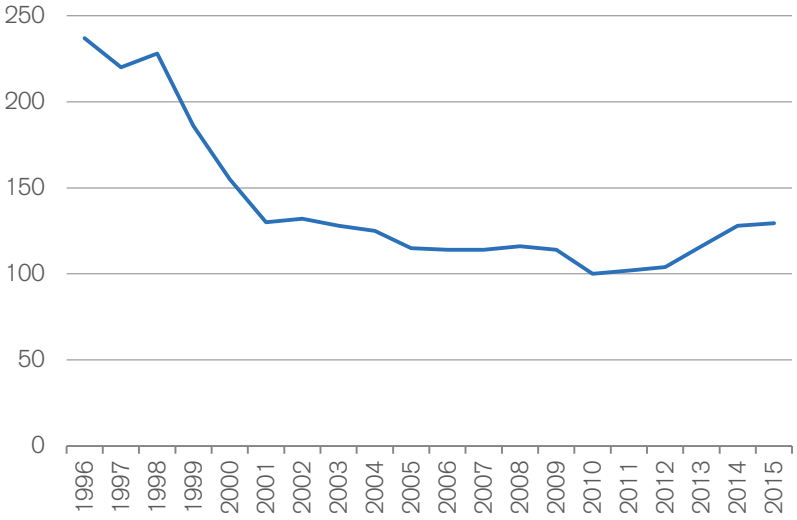
Statisticians would agree it is worth keeping an eye on the scale of these activities, but argue that they do not pose any substantive problems for the definition of GDP. This might be complacent as the current definitions designate households to be non-productive. If instead we are seeing the start of a social trend away from formal, defined work for stable domiciled firms, the existing production boundary will – like national boundaries for economic activity – become inherently blurred. In terms of scale, however, digitally driven substitutions within GDP are probably more significant. As the table at the end of this chapter suggests, there are many of these.

One substantial set of problems relates to the borderless and intangible nature of digital activity. As noted, consumers are increasingly using overseas platforms and e-commerce vendors. These may themselves locate different activities in different places – research & development, servers, payments, sales and marketing, support – as well as sourcing supplies and serving customers in many countries. It is also absolutely unclear how to attribute value in digital-value chains to different territories or indeed what happens in current statistics. "Factoryless production," whereby all production is outsourced overseas, has become

9. For more detail on these points, see Diane Coyle, "Do it Yourself Digital: The Production Boundary and the Productivity Puzzle," ESCoE Discussion Paper 2017–01, https://www.escoe.ac.uk/wp-content/uploads/2017/02/ESCoE-DP-2017–01.pdf.

Figure 3

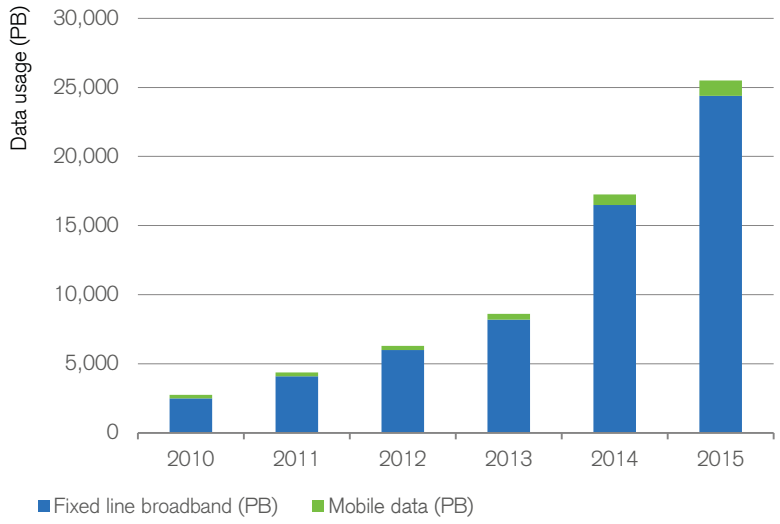
Implied GVA deflator: Telecommunications (2010 = 100)



GVA = Gross Value Added
Source: ONS

Figure 4

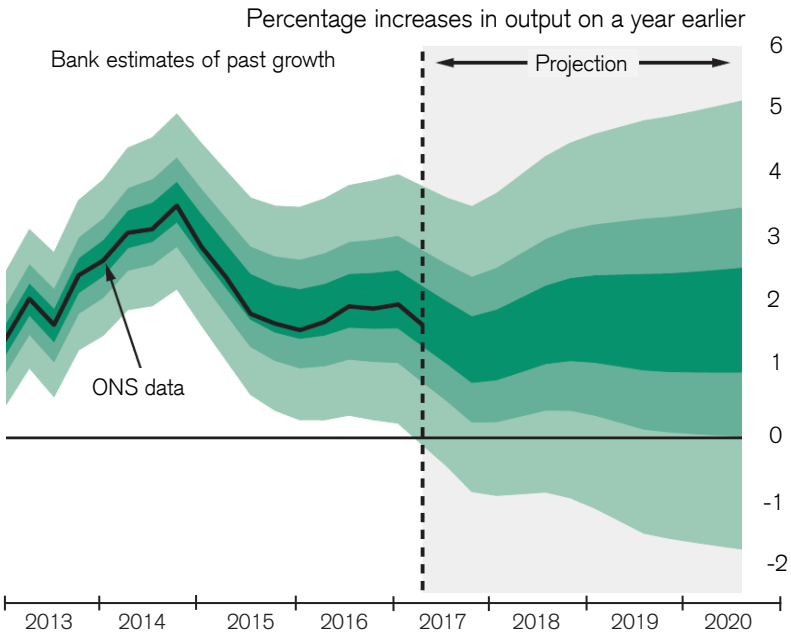
Data usage



PB = petabyte (1 petabyte is equal to 1,000 terabytes)
Source: Ofcom

Figure 5

2017 projections for GDP based on market interest rate expectations



Source: Bank of England Inflation Report August 2017

commonplace, for instance, practiced by 94% of the electronic components manufacturers in the S&P 500 index in the USA (70% in pharmaceuticals and 100% in toys and apparel).[10] Conventional statistics for imports of certain goods such as smartphone handsets or washing machines already do not net off the value of exported physical components (although a relatively new database is beginning to collect this value-added data). Still less do they account for the intangible value of the research & development exported in the design of the products – which after all might be embedded in an intra-company email of blueprints.

"There are problems related to the measurement of intangibles, or rather the lack of it"

There are problems related to the measurement of intangibles, or rather the lack of it. A big issue is the value of databases, not formally measured at all. Companies clearly believe their data to be valuable. Statisticians sometimes argue it nevertheless depreciates so quickly that their failure to measure it is not too serious. But many data-intensive companies disagree, and attribute high option value to data. The fact that data flows are growing so quickly supports their view.

10. K Bayard, D Byrne, D Smith, "The Scope of Factoryless Production in the United States," http://www.upjohn.org/MEG/papers/baybyrsmi.pdf.

The most important category of issues, certainly in terms of scale and implications for GDP, relates to calculating price indices and therefore real GDP. Even if we were confident about the measurement of GDP in nominal dollar or euro terms, this would be a significant challenge. The work statisticians currently do to adjust for innovation and the improving quality of certain ICT-related goods is small in scope. The effects of digital technology are far wider. The biggest challenges are likely to prove to be:

- New goods: conventional price indices bring in new goods as a new item rather than an improved and/or cheaper version of an old item. Thus generic pharmaceuticals are not counted as cheaper versions of their branded predecessors. This (well-known) bias is potentially large when there are many new goods: music streams or downloads rather than CDs, Airbnb rooms not hotel prices.
- Zero prices are not included at all, such as free news online rather than newspapers, or free software or games.
- A large category of zero prices for digital products in place of non-zero prices for physical products has been created by smartphones and apps. Many people no longer purchase: cameras, diaries, radios, maps, calculators, watches, voice recorders, GPS devices, guidebooks, and so on.
- Bundled prices are for the most part excluded, whereas bundling has become a common business strategy, especially in sectors such as communications and entertainment.

Of course, not everything that appears to be free is free; but the usual payment (in the form of personal data) is not captured in the statistics either, nor the imputed value of the associated advertising. At present, it is simply not known how big a difference any of these effects might make to the GDP deflator and the calculation of real GDP, but, even if each of them is small, their scope is broad. When the US Boskin Commission considered the problem innovation posed for measurement of the Consumer Price Index in the early 1990s, it concluded that measured inflation was about 1.1% a year above "true" inflation.[11] This led statisticians to start to quality-adjust some prices and was also followed by a move to "chain linking" or, in other words, updating the basket of goods used to calculate GDP every year instead of every five years, to better capture the rapid pace of innovation. However, this spreads the new-goods problem over time rather than eliminating it.

One way to appreciate the potential scale is to consider mobile telecommunications charges. This accounts for a reasonable proportion of the price of telecommunications output (33% in the UK, for example). The official communications price index varies between countries and indeed will depend on differences such as the extent of competition in mobile markets, or the extent of bundling of mobile with other services. In the UK, this index declined modestly from 1996 to 2000 and has since been approximately flat.

11. https://www.ssa.gov/history/reports/boskinrpt.html.

Yet, over that period, there have been massive improvements in engineering, such as the bit rate achieved on a single installed fiber. Although we do not know how much value consumers attribute to each bit (and this is a disadvantage with hedonic adjustment based on physical characteristics), the price reduction is manifest in the dramatic increase in data usage. Work in progress to calculate an alternative communications services price index is likely to show a steep decline rather than an almost flat price.[12]

If this reasoning is correct, and "true" inflation thanks to digital innovation is far lower than measured inflation, there are some significant implications. One is that the path of real GDP, and therefore the economic narratives built on it, will have to change. The conundrum of setting monetary policy in an economy characterized by major structural change will be still more troubling. The distributional implications could be significant too: almost everybody has a smartphone, but for people on low incomes, the services and goods that can be accessed online are less important proportionally than the basics of food, clothing and shelter.

The way forward

This discussion will have made clear that GDP is not a natural object, but a social construct. It has come to be regarded as the ultimate measure of an economy's success or failure. Countries compare their levels and growth rates of GDP in international league tables, and policies are justified in terms of how many billions or percentage points they might add. This single-minded focus on one number has always been more than it could bear, given how uncertain the figure is at the best of times due to data collection challenges, sampling error in surveys, seasonal adjustment and other complexities. Often, people do not realize the extent of the uncertainty as few statistical offices or other users indicate the margins of error.

"GDP is not a natural object, but a social construct"

One exception is the Bank of England, whose quarterly "fan charts" showing the probabilities its forecasters attach to different growth outcomes, indicate the past as well as the future. For instance, the Bank is 90% certain that UK GDP growth in the recent past has been between 0% and 4% a year, which is a huge margin.

Nevertheless, GDP has real strengths, above all that, in using market prices to value outputs, it makes explicit the weights placed on different activities in the economy. It can be adjusted to take account of the different leisure choices made in different countries,

12. R Heys and G Awano, "Measuring Output in the Information and Telecommunication Industries," Office for National Statistics 2016, http://www.upjohn.org/MEG/papers/baybyr-smi.pdf; also M Abdirahman, D Coyle, R Heys and W Stewart, "A Comparison of Demand Side and Supply Side Approaches to Deflating Telecoms Services Output," in progress.

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and for income distribution considerations.[13] It would be straightforward in principle to take account of the depreciation of natural capital or other assets not currently included in the national accounts. It is also still essential for macroeconomic policy: in thick fog, some light is better than none. For such purposes, GDP serves us reasonably well.

However, a growing number of researchers, as well as technologists and business people aware of the scope and pace of digitally driven change, believe there will need to be a significant change in the statistical framework for measuring the modern economy. There is an active research program under way, engaging economists and statisticians from many countries. The change may be slow, and not only because the UN process is rather bureaucratic. The conceptual issues are difficult. Collecting new statistics is costly, and the whole infrastructure for collecting existing ones needs to remain in place for the time being. New data sources and techniques will become available, but the process of developing these is still in its early days – again, there is an active research program. Standards also have a strong magnetic force: nobody wants to change until everybody changes. Statisticians, reporters, policymakers and the public are all locked into the existing standard.

"The most obvious kinds of change happening in people's lives now are not reflected anywhere in official statistics"

Still, it is possible to see what needs to be done and the outlines of a future statistical framework. It will be important to collect more descriptive statistics on all the digital changes, including cross-border flows, intangible assets and data flows. The most obvious kinds of change happening in people's lives now are not reflected anywhere in official statistics. Given budget constraints on statistical agencies, this will almost certainly involve online data sources and big data techniques. There are some private initiatives under way, and official statistical agencies are starting to follow suit.

There is difficult conceptual and data collection work to be done in thinking about cross-border activity. This is rather urgent at a time when trade has become much more prominent in policy debates, thanks to Brexit, but more broadly to the rise of nationalism in trade policy. If the US trade deficit with China turns out to be a statistical artefact, the sooner we understand what is happening, the better. How to track any flows internal to multinationals, including intangible assets and data, is not obvious. Nor is it obvious how to map the extensive multinational activity onto a national statistical framework.

The most important conceptual shift will be to move from a framework centered on short-term flows to an asset-based framework that enables the measurement of sustainable economic activity, or, in other words, the use of resources today without depleting capital and the possibilities for tomorrow. The most urgent task here is to develop measures of natural capital and appropriate depreciation rates, and this has barely started. Nor is it straightforward to calculate the rates at which renewable assets need to be restored to keep the stock constant or increasing. But that makes the need to start all the more pressing. The statistics enabling other parts of the national balance sheet to be put into place are more often available, but another important gap is the full public sector financial balance sheet. Policy arguments about the need or not for "austerity" will not be settled without this long-run perspective.

"Economic growth is more than important – it is a moral imperative"

Keynes famously said, "In the long run, we are all dead." He was arguing that the urgency of the moment meant it was no time to worry about the long-run implications of deficit spending. Keynes's long run has come, and along with it the bills for living for the day and not worrying about the future. Economic growth is more than important – it is a moral imperative. Growth is driven by innovations that ultimately improve and lengthen people's lives and well-being, reduce infant mortality, and create fulfilling work for more people. A growing economy is one where people have a sense of possibility for the future, of hope. However, the increase in GDP (as defined now) this year or this quarter is a narrow measure of what matters for people's economic welfare. The statistical framework of the future will need to measure prosperity and potential prosperity over a longer horizon, to capture people's access to resources that will enable them to live the kind of life they want to lead. This will take some time. Developing the current System of National Accounts and methods for measuring GDP took some 20–25 years. Now, though, just as in the 1930s, it is widely understood that the gap between the character of the economy in 2018 and the statistics we use to describe it has broadened so much that the statistical framework established around 70 years ago is no longer an adequate measure of economic progress. ■

13. Charles I. Jones, and Peter J. Klenow, 2016, "Beyond GDP? Welfare across Countries and Time," American Economic Review, 106(9): 2426–57. Also Dale W Jorgenson, "Within and Beyond GDP: Progress in Economic Measurement," forthcoming.

Table 1

Scope of digital changes raising measurement issues

I Activities in the Household Satellite Account (HHSA) – substitution across the production boundary	
DIY digital intermediation	Substitutes for (some elements of) market intermediation; new models of intermediaries & their location; use of household capital. Should be treated symmetrically with owner-occupier housing services if of sufficient scale?
Sharing economy	Data collection; use of household capital. If marketed, in principle in GDP; if not, in HHSA.
Voluntary household production of digital products	Substitutes for marketed output; should be included within production boundary? Measurement of household capital and resultant capital services.
II Activities in GDP – affected by digital business models	
Sampling	Prices of digital equivalent goods; outlet substitution bias.
Composition effects	Shift in industry composition especially to hard-to-measure sectors.
Intangibles	Hard to measure, increasingly included in investment statistics; consider investment in databases?
Digitization	Reducing sales of some marketed products; many of these are zero-price goods. Reduced fixed investment in commercial property (higher sales/bricks ratio, greater productivity of brick services). Cloud computing.
Second-hand goods	Nets out of Household Final Consumption Expenditure (HHFCE), apart from dealer's margin, but may be substituting for some new purchases.
Ad-funded free goods	Same in principle as commercial TV, bigger in scale. Deduct an imputation for cost of watching ads? Substitution between ad-funded vs. subscription vs. purchase to own consumption.
Cross-border effects	Substitution between different national GDP totals as consumers switch to overseas intermediaries – data collection issues. Attribution of value added in digital value chains.
III Activities in GDP – quality changes and price/real split	
ICT hardware	Sector is small, no acceleration. Smartphones hedonically adjusted for some features, but not for vast expansion of capabilities. Other price strategies.
ICT services	Not hedonically adjusted, but there has been significant scope and quality change. Free goods e.g. operating systems.
New goods	Old problem: a. Lower prices from new business models e.g. hotel prices & Airbnb; b. New digital goods (is a download a new product or a better CD?); c. Prices of bundled products; d. Boundary between consumer surplus and quality change, i.e. when does it make sense to try to measure value at the margin? e. Distinguishing real (physical) from real (constant exchange value) and impact of chain weighting?

Source: Diane Coyle, "Do It Yourself Digital: The Production Boundary and the Productivity Puzzle," ESCoE Discussion Paper 2017–01, https://www.escoe.ac.uk/wp-content/uploads/2017/02/ESCoE-DP-2017-01.pdf

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Main challenges to GDP

"China became the world's largest economy in 2014." "UK GDP grew by 0.1% in the first quarter of 2018." "In the Eurozone, inflation as measured by the Harmonized Index of Consumer Prices was up 1.4% in March 2018 compared to the previous March." Any scanner of websites that cover business news can read statements like these on any day of the week. Each statement relies on modern economic statistics using the System of National Accounts (SNA) as their basis. This chapter briefly outlines how the SNA came to have such a powerful (if background) role. Further, it discusses some of the many criticisms leveled at the SNA, and particularly at Gross Domestic Product, its centerpiece. These criticisms fall into two groups. The first group raises doubts about how accurately GDP is measured. The second is more about the relevance of GDP (and the SNA) as a guide to policy. Even if GDP is measured accurately, is it measuring anything which thoughtful people should be interested in?

Nicholas Oulton, member of the Centre for Macroeconomics at the London School of Economics

GDP and the SNA: A brief history

Simon Kuznets was one of the founders of national income accounting (he was awarded the Nobel Prize in Economics in 1971). In 1959, he published a study that revealed perhaps the most important empirical finding in the whole of economics (Kuznets 1959).[1] His discovery was that economic growth, i.e. the growth rate of GDP per capita, was much higher after the industrial revolution than it had been at any earlier time. So the countries fortunate enough to have passed through the industrial revolution experienced a dramatic acceleration in economic growth and (eventually) in living standards.

"The advent of great inventions does not necessarily lead to faster growth of per capita GDP on a sustained basis"

The industrial revolution therefore marks a new epoch in human history. To non-economists, the industrial revolution is usually characterized by the great inventions accompanying it, such as steam power and railways. But the advent of great inventions does not necessarily lead to faster growth of per capita GDP on a sustained basis. For a counter-example, consider the 15th and 16th centuries in Europe, which saw the invention of printing and improvements in shipbuilding and navigation such as the magnetic compass, which in turn led to the conquest and settlement of the Americas. But we now know that these great discoveries did not lead to an appreciable increase in the European growth rate.

1. He developed the argument further in Kuznets (1966).

How did Kuznets reach his dramatic conclusion? After all, in 1959, he only had data for 19 countries and these data only stretched back in most cases for about 80 years. He had no data for any country before the industrial revolution. The answer is that he employed a thought experiment. He took the growth rates of GDP per capita, which he had measured in his sample of countries (mostly in the range of 1%–2% per year), and then asked the question: suppose these growth rates had prevailed in earlier centuries, how low would the standard of living have been 200 or 500 years ago? He calculated that the standard of living would have been so low that no-one could have survived. But if they could not have survived, then we would not be around to do these calculations today. Therefore, growth rates must have been lower before the industrial revolution than after it. One can easily convince oneself of Kuznets' point by calculating what sum would grow to say USD 1,000 (roughly equal to the World Bank's global poverty standard for annual income today) if compounded at 1% over 200 years. The answer is USD 135, less than a dollar a day. Compounding over 500 years, the answer is less than seven dollars a year. Clearly, these income levels are impossible. Kuznets' conclusions have subsequently been amply confirmed by direct estimates of income levels and growth rates in pre-modern economies (e.g. Broadberry et al (2016) for Britain).

Uses of GDP

During World War II, pioneering estimates of GDP were used by the UK and US governments for planning the war. Estimates of GDP in current prices sufficed for this purpose since the main question was how much could be spent on the armed forces without reducing household expenditure to an unacceptable level. After the end of World War

II, the national income accounting revolution spread rapidly across the world. The United Nations, under the guidance of other pioneers like Richard Stone (awarded the Nobel Prize in Economics in 1984), took up the challenge of producing an internationally accepted System of National Accounts. The first version, all of 48 pages long, appeared in 1953. Subsequent versions have appeared in 1968, 1993 and 2008, and further updates are planned. The latest version (European Commission et al. 2009) has grown to 662 pages. For a time, the Soviet Union employed and enforced a rival system on its satellites, the Material Product System (MPS), based on Marxist principles. The disappearance of the Soviet Union has meant the disappearance of the MPS too, even in countries run by communist parties like China.

The post-war development of the SNA met the needs of Keynesian macroeconomic management, support for which was spreading rapidly. For this purpose, GDP is necessary in constant as well as current prices. Quarterly as well as annual estimates of GDP started to appear. Keynesian notions of macroeconomic management are now less popular than they once were, but central banks with a remit to target inflation are just as keen to receive high quality and frequent estimates of GDP and its main components such as consumption and investment.

"Keynesian notions of macroeconomic management are now less popular than they once were"

In parallel with the needs of monetary and fiscal policy, a new market for GDP and the SNA has arisen due to increasing interest in the problems of long-run growth and development, both in developing and developed countries. And this has sparked innovations in official statistics too, such as the capital and productivity manuals of the Organisation for Economic Cooperation and Development (OECD, 2001 and 2009, respectively). The first of these manuals on measuring capital enshrined the fundamental distinction between capital stocks and capital services, originally introduced by Jorgenson (1989), and showed how it could be incorporated into the SNA. Building on the pioneering contributions of Jorgenson and Griliches (1967) and Jorgenson et al. (1987), the second manual on productivity employed the concept of capital services to show how theoretically consistent measures of total factor productivity growth could be derived within the framework of the SNA.

With the rise of major new economic powers like China and more recently India, there has also been increasing interest in international comparisons of the size of different economies (GDP) and their relative standards of living (GDP per capita). The crucial institution here is the International Comparison Program (ICP) run by the World Bank in conjunction with the OECD. The 2005 round of the ICP included 146 countries, covering 95% of the world's population (World Bank 2008). The latest round in 2011 included 199 countries, though full results are available for only 177 (World Bank 2015). Just as national statistical agencies (NSAs) track prices over time for their domestic price programs such as the Consumer Price Index, so the ICP tracks prices across countries at a given moment in time, e.g. mid-2011, via a collaborative and coordinated network of NSAs. The prices of the individual products and the overall averages for aggregates like household consumption or GDP, all measured relative to US dollar prices in the USA, are known as Purchasing Power Parities (PPPs). In both the national and international programs, broadly the same methodology is used: "matched models" under which the agencies try to track the prices of identical models either over time or across space. The results can be controversial in some cases. China (and Asia generally) turned out to be considerably poorer under the 2005 comparison than many observers had expected. Following methodological changes, China's and Asia's rankings rose substantially in the 2011 ICP (Deaton and Aten 2017).

How accurately is GDP measured?

At least in countries with well-developed statistical systems, GDP in current prices (nominal GDP) is considered to be measured reasonably well (it may be a different matter in poor countries (Jerven 2013)). There is much more concern about GDP in volume terms, i.e. real GDP, because moving from nominal to real GDP requires deflating each component by an appropriate price index. There are two major issues with price indices. First, they may not make adequate allowance for quality change and for new goods. Second, for some components of GDP, price indices often do not exist and are thus replaced by proxies or conventions.

Bias in price indices

There has long been concern that price indices may understate quality change and not make adequate allowance for the appearance of new goods, thus leading to an overstatement of inflation and an understatement of real economic growth (very few researchers have advocated the opposite position, though it may be true for individual products[2]). Most of this evidence is for the USA, but there is no reason to think that other developed countries are any better.

2. For example, when the US Bureau of Labor Statistics introduced hedonic methods to measure commercial rents, it found that the new index rose more rapidly than the "matched models" index it was replacing. The reason was that the old method used "matched apartments" to measure rents. But, over time, the apartments being matched were getting older and less desirable, and this was reflected in the market by declining rents. So the old index was understating inflation in commercial rents and hence overstating growth in the real volume of housing services (Wasshausen and Moulton 2006).

Perhaps the strongest advocate of this view is Robert Gordon. His earlier work uncovered a huge underestimate of quality change in durable goods prices in the USA in the 19th and 20th centuries up until the early 1980s (Gordon 1990). For example, over the period from 1947 to 1983, he found that the rate of growth of the official producers' durable equipment deflator was 3% per annum too high and the official deflator for consumers' durable expenditure was 1.5% per annum too high. He reached this result by replicating the methods used by the US Bureau of Labor Statistics (BLS), but also using extensive non-official data, mostly successive issues of the Sears mail order catalogs. These gave prices together with descriptions of items like lawnmowers, sometimes accompanied by photographs, so he was able to apply the "matched models" method of statistical agencies. The "matched models" method involves tracking the price of the same model over time, thus holding quality constant.

In his more recent book (Gordon 2016), he has argued strongly that growth in the US standard of living since the Civil War and up to the 1970s is severely understated by official statistics because of the revolutionary new products that became available to the typical family over these decades (flush toilets, cars, radio, films, TV, air travel, etc.) are not given full credit in the national accounts. The Advisory Commission to Study the Consumer Price Index (1996), commonly known as the Boskin Commission (of which Gordon was a member), argued that the Consumer Price Index (CPI) had been overstating US inflation by over 1% per year for the years leading up to 1996 due to a combination of factors including inadequate allowance for new goods and quality change. Other factors were substitution bias, outlet bias and formula effects.

"Economic theory has long known how to cope with new goods (or vanished old goods) in calculating a price index"

There are two problems with incorporating the effect of new goods on inflation. First, by virtue of its newness, it may be some time before it is introduced into the price index. Second, even when it has been introduced into the index, its effect on the standard of living will be understated since only price changes after its introduction will affect the index. Everyone may agree that the new goods represent a significant increase in welfare, but this is not captured in the price index and so does not lead to an impact on real income. The first problem is an administrative and budgetary one. The second is more conceptual.


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In fact, economic theory has long known how to cope with new goods (or vanished old goods) in calculating a price index. In the case of a new consumer good (or a new input), we should treat it as if it had always existed, but at a price where demand for it is reduced to zero, i.e. its reservation price, also called its virtual price. More precisely, the reservation price is the minimum price at which there is zero demand for the specific good. Prior to its appearance, the new good's reservation price should be included in the price index, and the good's actual price should be included after its appearance (Hicks 1940). This makes it clear why ignoring new goods leads to an overestimation of price rises and a consequent underestimation of real growth. For the price of the new good has in fact fallen from its reservation level to its observed level, which is necessarily lower.

The problem is how to estimate the reservation price. Researchers have done this for individual products, most notably Hausman (1997) for a new brand of breakfast cereal (Apple Cinnamon Cheerios), see also Hausman (2003), but the results are controversial since they are dependent on particular assumptions about demand and on econometric methods (Groshen et al. 2017). A more easily implementable approach, based on a Constant Elasticity of Substitution (CES) demand system (Feenstra 1994; Redding and Weinstein 2016), may be appropriate in some contexts, but also suffers from restrictive assumptions about the pattern of demand and has the unpalatable property that the reservation price is infinite. More to the point, no statistical agency currently uses the reservation price approach to measure the impact of new goods. So the problem has been parked and we must wait for further research to see whether a practical method can be developed (here "practical" means, in part, "within the budget that governments are willing to allot to statistical agencies").

"It is probably no coincidence that there has been renewed interest recently in the possible understatement of GDP growth"

How much difference improved methods would make is hard to judge, though ballpark figures like an additional 0.5% per annum on GDP are sometimes mentioned. It is probably no coincidence that there has been renewed interest recently in the possible understatement of GDP growth since GDP and productivity growth seem to have slowed down at least since the Great Recession began at the end of 2007 (or perhaps earlier). But there seems little reason to ascribe the slowdown to mismeasurement since the latter was at least as great a problem prior to the appearance of a slowdown (Byrne et al. 2016; Syverson 2017).

Statistical agencies will no doubt implement improved methods as time goes on and research delivers new solutions.[3] But a point to bear in mind is that price indices are almost never revised. So the shortcomings of earlier methods will remain in the historical record, even if the most recent years are better measured.

Missing or inappropriate price indices

Real GDP can be measured either from the expenditure side, GDP(E), or from the output side, GDP(O). Consistency requires that the two measures should be equal. On the expenditure side, we have the familiar formula, $GDP(E) = C + I + G + X - M$.

Private consumption (C) typically accounts for 60%–65% of GDP and here we can rely on the prices gathered for the Consumer Price Index. The CPI program is the largest and best-funded of all price-gathering programs. Gross fixed investment (I) accounts for another 20% or so of GDP. Here we have to rely on the much less well-funded Producer Price Index program. Exports (X) and imports (M) account for a large fraction of GDP (in some small countries a multiple of GDP), but what matters for GDP is the balance, typically a small proportion of GDP (plus or minus 1%–3%). Since rich countries these days tend to trade mainly with each other and the goods imported and exported are similar, any errors in export and import price indices will tend to cancel out.

"The shortcomings of earlier methods will remain in the historical record, even if the most recent years are better measured"

That leaves government consumption (G) – defense and public administration, education, and health – as the remaining major component of GDP(E) and here there is a serious deficiency. Until recently, most countries measured real government output by real government input (essentially hours worked adjusted for the composition of the labor force), which left very little room for productivity improvement and allowed for no improvements in quality. Nowadays, some countries try to do better by using a collection of output measures weighted together by costs. For example, the output of the education sector can be measured by a weighted average of the numbers passing through each stage of the school system, weighted by the costs of providing each stage. This is better than measuring education output by hours worked in this sector, but hardly addresses the quality issue. The quality issue is perhaps greatest in health, where there have been large improvements in health outcomes, sometimes achieved at low cost; for example, the incidence of heart attacks

3. See Bean (2016) for a comprehensive set of recommendations tailored to the British case for improving economic statistics.

and strokes has been greatly reduced by statins and aspirin. It is clear that these improvements are not reflected in the price indices for health output and expenditure. Improving these indices is an active area of research (Groshen et al. 2017).

On the output side, GDP is the sum of value added across industries. Here the appropriate price indices are Producer Price Indices and (where they exist) Service Producer Price Indices (ideally, inputs need to be deflated separately from outputs, but this is not always the case). In practice, statistical agencies tend to put much more weight on the expenditure side for estimates of real GDP. The reason is that the bulk of GDP(E) is private consumption, where price indices are comparatively well measured. So (for example), the UK's Office for National Statistics adjusts the annual estimates of the growth of real GDP(O) so that they conform to the growth of real GDP(E) to within 0.1% per annum (Lee 2011). They do this by adjusting the growth rates of private service industries. The reason, no doubt, why the adjustment falls on private services is that this is where price indices are either inadequate or missing, so that they have to be replaced by proxies like the CPI.

A large fraction of the output of a modern economy (often larger than the proportion accounted for by manufacturing) is made up of industries supplying mainly intermediate services to business, such as finance and business services of all kinds (accountancy, advertising, contract cleaning, design, legal, management consultancy, computer and software services, etc.). Here price indices are often of low quality or missing altogether (Timmer et al. 2010, pages 90–94). To the extent that we care just about GDP, this does not matter since these problems are largely absent on the expenditure side: business services are an intermediate product so drop out of GDP(E). But, if we also care about what is happening in individual industries, say because we want to trace the origins and impact of the Great Recession, then we will also need better price indices for important industries like finance and business services.

Cross-country comparisons of price and income levels

Although it has attracted far less attention than possible deficiencies in consumer and producer price indices, the accuracy of PPPs is just as pressing an issue. There are conceptual problems that are yet to be fully resolved. To take one example, the relative income levels yielded by successive rounds of the ICP are not consistent with extrapolating from one round to the next using the national accounts of the countries studied. Whether this should be treated as a fact of life or adjusted for in some way is still a matter of debate. One extreme is to largely ignore national accounts and base international comparisons solely on successive PPPs. The other extreme is to pick the "best" single set of PPPs and ignore the others; this approach makes maximal use of national accounts. The debate continues here and also in regard to finding some alternative compromise (Oulton 2015).

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GDP and globalization

In 2016 Ireland's Central Statistical Office announced that Irish real GDP rose by 26.3% in 2015, quite possibly a world record for a single year's growth and certainly putting China in the shade. This astonishing figure did not result from any revisions to underlying data nor from methodological changes but instead was due to application of the existing rules as approved by Eurostat. GDP measures output generated by residents (persons and corporations) of a given economic territory. But globalization has made residence a somewhat slippery concept. And this has been compounded by the rising importance of income accruing to intellectual property, e.g. royalties and fees for the use of technology and brands. Often these payments are made between subsidiaries of a multinational company. So where the subsidiary receiving these income flows is located can make a big difference to GDP, particularly if it is located in a small country. And it is no secret that location is mainly determined by tax considerations.

"Future versions of the SNA will no doubt try to find a more realistic basis for the definition of residence"

What seems to have happened in the Irish case is that one or more large multinationals moved the subsidiary which licenses technology and brands to the rest of the group to Ireland, causing the large jump in Irish GDP in 2015. Of course, this made little or no difference to the Irish standard of living (real household disposable income in Ireland rose by 4.6% in 2015, due to continuing recovery from the global financial crisis). And from a planetary point of view it was just a redistribution of, rather than an increase in, global output. Nevertheless it makes the interpretation of Ireland's GDP, and that of any other country in the future subject to such shifts of residence, problematic. It may well be the case that the Irish subsidiaries generating these huge income flows are not just located in but managed from Ireland. But it is also very likely that the intangible assets generating these flows were not created in Ireland but elsewhere, probably mostly in the USA. Future versions of the SNA will no doubt try to find a more realistic basis for the definition of residence.[4]

4. See OECD (2016) for a discussion of the Irish case.

Should we still care about GDP?

The commonest criticisms of GDP as a target of policy are the following:

1. GDP is hopelessly flawed as a measure of welfare. It ignores leisure and women's work in the home.
2. GDP ignores distribution. In the richest country in the world, the United States, the typical person or family has seen little or no benefit from economic growth since the 1970s. But, over the same period, inequality has risen sharply.
3. Happiness should be the grand aim of policy. But the evidence is that, above a certain level, a higher material standard of living does not make people any happier. So we should stop looking for policies to raise GDP and look instead for policies that promote happiness.
4. Even if higher GDP were a good idea on other grounds, it is not feasible because the environmental damage would be too great. The planet is finite; so if the truly poor in the Third World are to be allowed to raise their standard of living by a modest amount, then consumers in the rich countries will have to accept a lower standard of living, i.e. lower not higher GDP per capita should be the aim for them.

I consider the first three criticisms in turn. Space precludes a discussion of the fourth.

1. "GDP is hopelessly flawed as a measure of welfare"

GDP is and always was intended to be a measure of output, not of welfare. In current prices, it measures the value of goods and services produced for final consumption, private and public, present and future; future consumption is covered since GDP includes output of investment goods. Converting to constant prices allows one to calculate growth of GDP over time (or differences between countries across space). The exclusion of home production and leisure is not due (I believe) to prejudice against women, but to the desire on the part of national income accountants to avoid imputations wherever possible. However, it is not very difficult to include values for leisure and home production provided the necessary data on time use are available and provided one can decide on an appropriate wage rate to value time spent in non-market activities.

"One can imagine a social welfare function that has GDP as one of its components along with health, inequality, human rights, etc."

Though not a measure of welfare, GDP can be considered as a component of welfare. The volume of goods and services available to the average person clearly contributes to welfare in the wider sense, though of course it is far from


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being the only component. So one can imagine a social welfare function that has GDP as one of its components along with health, inequality, human rights, etc. (see comments below on the Stiglitz-Sen-Fitoussi Report).

GDP is also an indicator of welfare. In practice, in cross-country data, GDP per capita is highly correlated with other factors that are important for human welfare. In particular, it is positively correlated with life expectancy, negatively correlated with infant mortality, and negatively correlated with inequality. Figures 1–3 at the end of this chapter illustrate these facts for some 126–146 countries in 2005 (actually these charts, from Oulton (2012), plot household consumption per capita rather than GDP per capita against each welfare measure; but the picture for GDP would be very similar). In other words, richer countries tend to have greater life expectancy, lower infant mortality, and lower inequality (although this last relationship is not a linear one: some middle-income countries have high inequality, but nonetheless the richest countries are also the most equal ones). Correlation is not necessarily causation, though one might certainly make the case that higher GDP per capita causes improved health (Fogel, 2004; Deaton, 2013).

Life expectancy rose steadily throughout the 20th century and is still rising on average in the 21st century. This means that people have more years in which to enjoy the higher consumption they now receive, an aspect of welfare which is not captured just by the GDP statistics. But, recently, the USA has seen a rise in mortality among less-educated, middle-aged whites due it seems to self-harming behavior – drug and alcohol dependency, accidents and suicide (Case and Deaton 2017). Whether this is a specifically American phenomenon, related perhaps to deficiencies in the US social safety net (Edin and Shaefer 2015), or whether the same phenomenon will appear in other developed countries remains to be seen.

According to the Commission on the Measurement of Economic Performance (the Stiglitz-Sen-Fitoussi Commission), policy should be concerned with well-being, and well-being is multi-dimensional (Stiglitz et al., 2009, page 15): "To define what well-being means a multidimensional definition has to be used. Based on academic research and a number of concrete initiatives developed around the world, the Commission has identified the following key dimensions that should be taken into account. At least in principle, these dimensions should be considered simultaneously:

1. Material living standards (income, consumption and wealth);
2. Health;
3. Education;
4. Personal activities including work;
5. Political voice and governance;
6. Social connections and relationships;
7. Environment (present and future conditions);
8. Insecurity, of an economic as well as a physical nature."

Few will disagree that these dimensions of life are important for human welfare and no-one can object to improved measurement. There is clearly a role for government in measuring and tracking these dimensions. To what extent, however, a dimension like "social connections and relationships" should be objects of government policy is open to question. It is doubtful in my view that effective policy levers exist. And, even if they did, the scope for a vast extension of the reach of government is worrying.

If one sticks to measurement and is somewhat less ambitious than the Stiglitz-Sen-Fitoussi Report, then further progress is possible. Jones and Klenow (2016) use an expected utility framework to combine measures of life expectancy, inequality and consumption to construct what they call a consumption-equivalent welfare measure for a large sample of countries. Their measure turns out to be highly correlated with GDP per capita.

2. "Growing GDP is pointless since most people don't benefit"

This claim is most often made in relation to the USA. Many people assert that real household income levels there have stagnated since the 1970s, despite labor productivity and GDP per capita growing quite rapidly.[5] It is non-controversial that income inequality has been rising for decades in the USA, but does this mean that the typical household has received no benefit from growth? A comprehensive examination of these issues appears in an article by Wolff et al. (2012). Their results reveal quite a different picture.

They define a number of income concepts that are superior to GDP as a measure of household welfare: Comprehensive Disposable Income (CDI), Post Fiscal Income (PFI), and their preferred measure, the Levy Institute Measure of Economic Well-Being (LIMEW). CDI is household income, including property income (on an annuitized basis), less taxes plus cash and non-cash benefits. PFI adds to this individual public consumption (e.g. publicly provided health and education, but not things like defense). Finally LIMEW adds the value of household production. These measures are all per household. For LIMEW they also report equivalent median income; "equivalent" means that corrections are made for changing household size and composition. They estimated each of these income measures over the period 1959–2007 and for various sub-periods. Since measuring economic welfare over time is the objective, they convert each measure to real terms using the CPI and consider the median household values.

"It is non-controversial that income inequality has been rising for decades in the USA, but does this mean that the typical household has received no benefit from growth?"

The growth rates of these four concepts of household income appear in lines 1–4 of Table 1 at the end of this chapter, with the last column showing growth over the whole 1959–2007 period. The main point to take away is that median LIMEW grew at 0.67%, and equivalent median LIMEW at 1.01% p.a. Furthermore, if we look at the sub-periods in the table, we can see that there is no sign of a slowdown, except perhaps in 2004–2007. Interestingly, the period 1959–1972, supposedly the golden age of economic growth, was actually a comparatively poor one for households. Far and away, the best period for households was 1982–1989, which coincides roughly with the Reagan presidency if we are allowed to ignore 1980–1981, the Volcker deflation and recession.[6]

The second take-away from Table 1 is that all these measures grew much less rapidly than GDP per capita, shown in line 9, which grew at 2.18% p.a. over this period. None of the household measures grew at anything like this rate, e.g. their preferred measure, median LIMEW, grew at only 0.67% p.a. as mentioned before. What accounts for this huge gap? Wolff et al. do not discuss this much, but here is my explanation:

- Household size and composition have been changing: there are fewer children and more single households (Gordon, 2009). Hence equivalent median LIMEW grew faster than median LIMEW by some 0.34% p.a. (the same household income is spread over a smaller number of people).
- If the distribution of income had stayed the same, then mean LIMEW would have grown at the same rate as the median. In fact, the mean grew faster than the median by 0.30% p.a. According to my estimates, equivalent mean LIMEW (line 6) therefore grew by 1.31% p.a.
- LIMEW is deflated by the CPI, while GDP is deflated by the GDP deflator (more precisely, each component of GDP is deflated by its own price index). It so happens that the CPI grew more rapidly than the GDP deflator: the difference was 0.45% p.a. over 1959–2007 (line 10). Employing the GDP deflator rather than the CPI raises the growth of equivalent mean LIMEW to 1.76% p.a. (line 7). Arguably it would be better to use the price index for personal consumption expenditure (PCE) from the US National Income and Product Accounts (NIPA) as a deflator. Methodologically, the PCE is superior to the CPI since it is an annually chained Fisher index, while the CPI is a bi-annually chained Laspeyres.[7] Line 8 shows that the result would then have been much the same as deflating by the GDP deflator.

5. There is considerable evidence that mean real wages, analyzed by age, gender and educational level, have stagnated since the 1970s. But this does not quite establish that living standards have also stagnated since the composition of the labor force might have shifted to better-paying jobs. And property income, taxes and benefits have to be taken into account too.

6. GDP per capita was 2.8% below its 1979 level in 1982, which helps to explain some of the rapid growth after 1982. GDP per capita grew at 2.43% p.a. over 1980–88, still faster than any sub-period except 1959–72.

7. McCully et al. (2007) show that from Q1 2002 to Q2 2007, almost half of the 0.4 percentage point difference between the two deflators in annual growth rates was explained by the formula effect; most of the rest was explained by differences in relative weights due to the use of different surveys.

- Much of the remaining gap between median LIMEW and GDP per capita can probably be explained by two factors. First, investment has grown faster than consumption over this period, pulling up GDP in relation to consumption.[8] Second, household production is included in LIMEW, but not in GDP: household production grows slowly because, by assumption, there is zero technical progress. These factors may account for the remaining 0.42% p.a. of the difference between the growth rates of median LIMEW and GDP per capita over the 1959–2007 period.

These remarks are not meant to suggest that GDP per capita is a better measure of welfare than (equivalent) median LIMEW, but rather to explain how there can be such a large difference between the growth rates of the two.

The conclusion is that the median US household has gained significantly from economic growth since 1959. This remains the case even though the median household would have gained more (to the extent of 0.30% p.a.) if inequality had not widened. However, most of the gap between the growth in GDP per capita and in median LIMEW is not due to rising inequality, but to the other factors detailed above. Furthermore, and contrary to the common view, there were large gains in the 1980s, which continued, albeit at a slower rate, in the 1990s and even into the 2000s.

"One can move "beyond GDP" to explain how household welfare relates to GDP"

The above analysis is an attempt to show how, while still making use of the SNA, one can move "beyond GDP" to explain how household welfare relates to GDP. The main point is that rising inequality has certainly reduced the gains from higher productivity that would otherwise have accrued to the typical US household, but has not eliminated these gains completely.

The analysis stops in 2007, the last year of the boom. The median household has certainly done worse during the Great Recession and its aftermath, mainly because of lower productivity growth and declining labor force participation. Whether these adverse headwinds will continue to operate is an important question. On the one hand, there are techno-optimists like Brynjolfsson and McAfee (2014) who argue that developments in AI are about to open a cornucopia of productivity growth. On the other hand, there are techno-pessimists like Gordon (2016) who

8. This is probably because the prices of investment goods have been falling in relation to consumption goods, i.e. technical progress has been more rapid in investment goods. To keep the capital output ratio constant in current price terms, investment has to grow faster than consumption in steady state.

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argue the opposite: the great innovations are all in the past and the impact of developments in artificial intelligence and information technology will be much more limited in the future. Gordon's pessimism finds support in Fernald's work on the growth of total factor productivity (TFP) in the USA. He finds that TFP growth started to slow down after 2003, four years before the onset of the Great Recession. But elsewhere I have argued that this pessimism is overdone (Oulton, 2018). Much of the slowdown in both labor productivity and TFP since 2007, particularly in Europe, is due to the Great Recession itself. So when the Western economies are fully recovered productivity growth can be expected to revive as well.

Should GDP be adjusted for inequality?

There have been a number of suggestions for discarding GDP in favor of a measure that takes explicit account of inequality. One of the best-known measures is based on the Atkinson index of inequality (Atkinson, 1970):

$$Z = \left(\frac{1}{N} \sum_{i=1}^{N} y_i^{1-\varepsilon} \right)^{1/(1-\varepsilon)}, \quad 0 \le \varepsilon < 1$$

where y_i is the income of the i-th person (or household), N is the number of people (or households) and ε is a parameter measuring "inequality aversion." If $\varepsilon = 0$ then society cares nothing for inequality, in which case the Atkinson measure reduces to GDP per capita (or per household).

In the standard treatment, of which the Atkinson index is an example, inequality is bad per se, though people may differ in the extent to which they are inequality averse. I would argue that our moral intuitions about inequality are too complex to be wholly captured by this formulation. In particular, the crucial issue of merit or desert is omitted. If the Atkinson/Sen approach were the whole story, then social welfare would be raised by abolishing two institutions (among others): the national lotteries run in many countries and the Nobel prizes. Both increase inequality unambiguously. Indeed Nobel prizes must be the most unequally distributed of all forms of income: only a dozen or so individuals receive one each year out of a world population of some 7.5 billion.

Nobel prizes could be justified on Rawlsian grounds: monetary incentives are needed to induce the effort required to make discoveries that benefit everyone, including the worst off. But suppose that it could be conclusively shown that the monetary rewards are not necessary, and that the prize winners (and their less-successful colleagues) would have expended the same effort in exchange for just the honor and glory alone? I suspect that most people would still be quite happy to see the winners receive a monetary reward, even if it was not economically required. This is because they are perceived to deserve it. With national lotteries, a different form of desert comes into play. In the UK version, some winners receive GBP 20 million or more and, in one sense, no-one is worth this amount. But anyone can buy a lottery ticket and, as long as the lottery process is perceived as fair, most people are quite happy with the outcome.

Merit or desert is a complex issue and it may be that people's views are not entirely consistent. Who gets the money and for what may well make a difference. The large rewards paid to professional footballers may be seen by many people as justified (as long as they are playing well), in contrast to the similar-sized rewards paid to some bankers, especially after the global financial crisis.

Then there is the issue of redistribution, particularly welfare payments. Here it is obvious that notions of merit or desert play a major role in most people's thinking. Paying welfare benefits to a former soldier with post-traumatic stress disorder may well be seen as one thing; paying the same amount to a drug addict with addiction-induced mental health problems may seem quite another. Whether justified philosophically or not, the point is that moral perceptions such as these exist and, in a democracy, they should be taken into account.

In summary, it is not clear that the Atkinson index would meet with universal approval, even setting aside the issue of varying "taste" for inequality (the parameter ε). There is certainly a case for developing an index that takes explicit account of inequality as does the Atkinson index. But, fortunately, we do not need to choose between GDP and the Atkinson index (or any similar one). We are free to use and argue for both.

3. "Raising GDP per capita is pointless as it doesn't make people any happier"

Surveys of well-being or happiness repeatedly show that, within any given country at any point in time, richer people report themselves to be happier than poorer people. But, when the same survey is repeated in the same country over time, there is no rise in the average level of happiness despite the fact that per capita income has gone up. Most of the time series evidence is for the USA. This result is known as the Easterlin paradox.[9]

The commonest explanation for the paradox and the one suggested by Easterlin himself is that, at least above a certain level of income, people care more about their relative position in the income scale than they do about their absolute position. They are motivated by envy of those more successful than themselves and also by the satisfaction obtained by looking down on the less successful, rather than by the pure desire for material goods. This explanation reconciles the cross-section and time-series evidence. But it leaves the implication that stopping growth would have no effect on happiness. Also, more redistribution from rich to poor would raise overall happiness, given that the rich are less numerous than the poor. At least this would follow if we take a utilitarian view and provided that redistribution did not reduce GDP too much through adverse incentive effects.

I must admit that I am puzzled by these survey results, mainly because they are inconsistent with other facts about people's behavior. First,

9. Easterlin (1973). The time series evidence has been disputed by Stevenson and Wolfers (2008).

one might ask if people care mainly about their relative position, why has there been so much fuss about the financial crisis? After all, for most people in most countries, the drop in income has been (on this view) trivially small, no more than 5%, and, furthermore, it fell disproportionately on the rich (at least initially). Second, if people care about their relative position, why does this have to be expressed in terms of annual income? After all, many workers in developed countries today can work part time if they want to. Consider two workers, A and B. A has a higher daily rate of pay, but chooses to work only three days a week. B earns less per day, but chooses to work five days a week, so his annual income is higher than A's. So why can't A boast that his daily rate of pay is higher than B's even if his annual earnings are lower? That way he can satisfy his desire to lord it over B while still enjoying a leisurely lifestyle. In other words, a concern for relative position does not necessarily force people to work harder or longer than they would otherwise wish to do. But perhaps B-types are commoner than A-types. Surveys of part-time workers regularly show that many would like to work longer hours if only they could.

"People's leisure choices provide powerful evidence against the view that only relative position matters"

In fact, people's leisure choices provide powerful evidence against the view that only relative position matters. The classical economists argued that the amount of time people were prepared to work depended on the range of goods and services available for consumption. This was the basis for Adam Smith's "vent for surplus" theory of international trade, which was elaborated by John Stuart Mill (1871, Book III, chapter XVII):

"A people may be in a quiescent, indolent, uncultivated state, with all their tastes either fully satisfied or entirely undeveloped, and they may fail to put forth the whole of their productive energies for want of any sufficient object of desire. The opening of a foreign trade, by making them acquainted with new objects, or tempting them by the easier acquisition of things which they had not previously thought attainable, sometimes works a sort of industrial revolution in a country whose resources were previously undeveloped for want of energy and ambition in the people: inducing those who were satisfied with scanty comforts and little work, to work harder for the gratification of their new tastes, and even to save, and accumulate capital, for the still more complete satisfaction of those tastes at a future time."

Let us imagine that over the roughly 220 years since the beginning of the Industrial Revolution in Britain, process innovation has taken place at the historically observed rate, but there has been no product innovation in consumer goods (though I allow product innovation in capital goods). The UK's GDP per capita has risen by a factor of about 12 since 1800.[10] So people today would have potentially vastly higher incomes than they did then. But they can only spend these incomes on the consumer goods and services that were available in 1800. In those days, most consumer expenditure was on food (at least 60% of the typical family budget), heat (wood or coal), lighting (candles) and clothing (mostly made from wool or leather). Luxuries like horse-drawn carriages were available to the rich and would now in this imaginary world be available to everyone. But there would be no cars, refrigerators, washing machines, dishwashers or smartphones, no radio, cinema, TV or Internet, no rail or air travel, and no modern health care (e.g. no antibiotics or antiseptics). How many hours a week, how many weeks a year and how many years out of his/her expected lifetime would the average person be willing to work? My guess is that, in this imaginary world, people would work a lot less and take a lot more leisure time than people do today. After all, most consumer expenditure nowadays goes on products that were not available in 1800 and a lot on products not invented even by 1950.[11]

"Policy should take people as they are, not as others would have them"

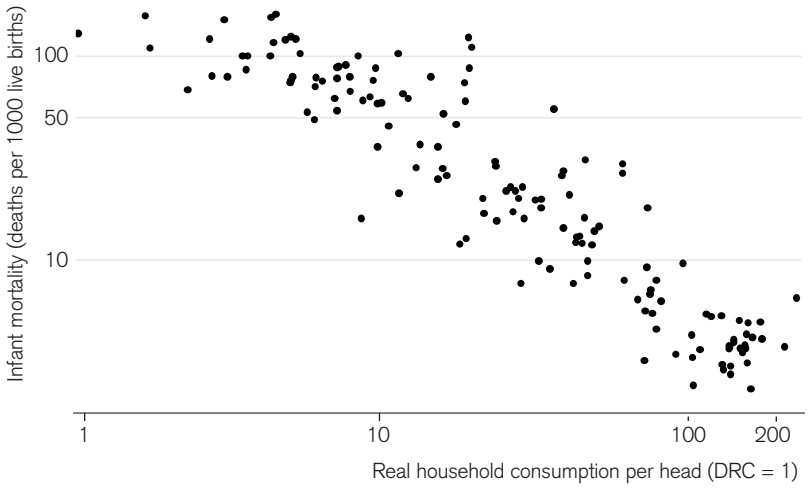
Overall, the proportion of time devoted to market work has not changed much in the last century, though this masks differences between women whose contribution has been rising, while that of men has been falling. But the rough constancy of the labor/leisure choice may be somewhat of an accident, produced by a battle between product and process innovation. There is no guarantee that this constancy will persist. If consumer product innovation falters, then I would expect leisure to rise. Of course other factors are at work here too: increased longevity, itself probably a product of economic growth, is generating pressure for increased work effort.

In summary, people's choice between labor and leisure demonstrates that they value higher consumption in an absolute and not just a relative sense. So rising GDP per capita would be in accordance with people's desires and preferences. Philosophers and social critics may object that the average person's desires and preferences are trivial, ill-informed and misguided (an attitude which can be traced back at least as far as Plato's Republic), but policy should take people as they are, not as others would have them.

10. Source: spreadsheet accompanying Maddison (2003).
11. Only about a tenth of the family budget goes on food nowadays and, even within the food basket, many items were not available in 1800.

Figure 1

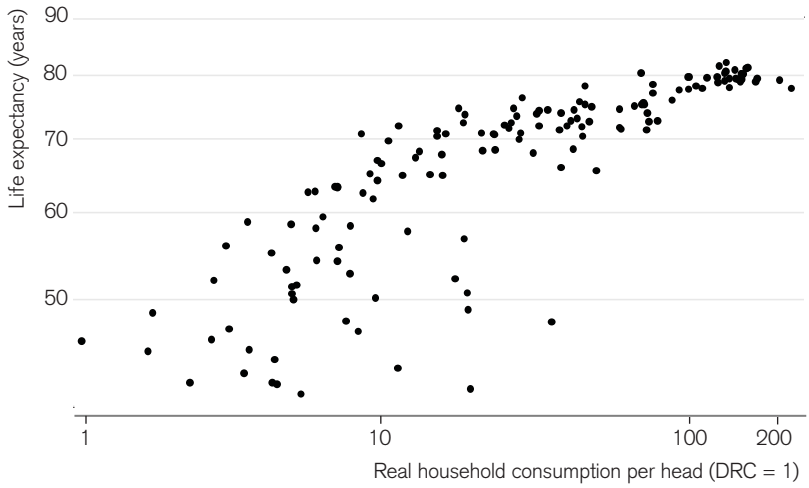
Infant mortality vs. household consumption per head
(log scales)



Note: 146 countries, household consumption deflated by EKS Fisher PPP.
Source: Oulton (2012)

Figure 2

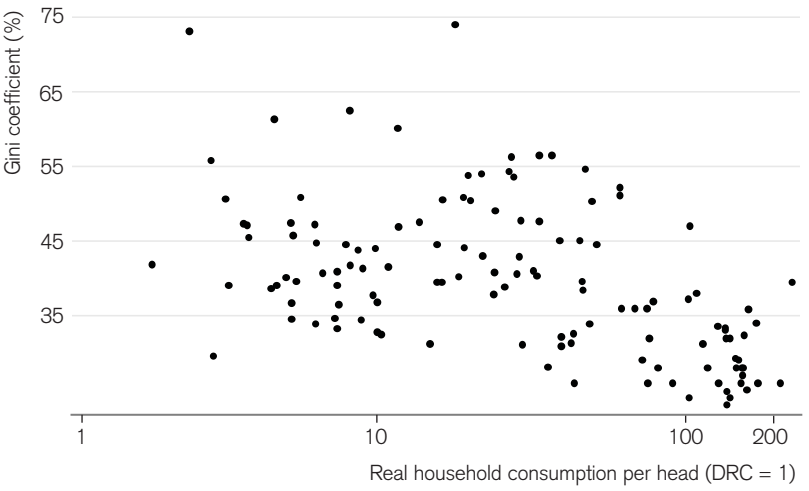
Life expectancy vs. household consumption per head
(log scales)



Note: 144 countries, household consumption deflated by EKS Fisher PPP.
Source: Oulton (2012)

Figure 3

Inequality (Gini) vs. household consumption per head
(log scale for household consumption)



Note: 126 countries, household consumption deflated by EKS Fisher PPP.
Source: Oulton (2012)

Conclusion: Not fade away?

The thought experiment just discussed suggests another one. Assume that technical progress continues to raise labor productivity over the next century at something like the rate experienced in the last 100 years. Will the typical consumer in Western societies take the benefits in the form of ever-increasing leisure? If so, consumers would be increasingly satiated with the goods and services that GDP measures. So, in this era of material abundance, GDP might come to be viewed as not wrong, but increasingly irrelevant. Such societies would probably have their share of problems due to the uses to which some people might put their ever-more-abundant leisure. But the analysis of such problems would not be helped much by the GDP statistics.

This second thought experiment envisages the same scenario as the first: no new consumer goods or services. We know that the two centuries since 1800 have seen an enormous variety of new consumer goods invented and made available on the market. It seems to me very unlikely that this inventiveness will simply come to a dead halt in the foreseeable future. So I expect new consumer goods to appear in a steady stream. On this count alone, GDP and the SNA will continue to be useful. Also much of the rest of the world outside the magic circle of Western societies remains poor. Today's poorer countries will likely retain an interest in GDP for many decades to come.

Throughout its more than 60-year official life, the SNA has expanded to address new concerns. The "core" SNA is now buttressed by satellite accounts covering interactions between the economy and the environment and household activities. I expect this process to continue and deepen as international discussions proceed toward agreeing on a successor to the 2008 SNA. ■

Table 1

Real income measures, per capita and per household, in the USA: annual percentage rates of growth, 1959–2007

	1959–1972	1972–1982	1982–1989	1989–2000	2000–2004	2004–2007	1959–2007
Deflated by CPI-U							
1. Median CDI	1.22	-0.29	2.16	0.88	0.62	0.16	0.85
2. Median PFI	1.55	-0.38	2.16	1.00	0.69	0.65	0.98
3. Median LIMEW	0.36	-0.68	2.82	0.93	0.96	0.22	0.67
4. Equivalent median LIMEW	0.94	-0.13	3.22	0.97	0.84	0.42	1.01
5. Mean LIMEW	0.53	-0.41	2.87	1.90	0.22	0.73	0.97
6. Equivalent mean LIMEW	1.11	0.14	3.27	1.94	0.10	0.93	1.31
Deflated by GDP or PCE deflator							
7. Equivalent mean LIMEW							
(deflated by GDP deflator)	1.02	1.26	3.64	2.74	0.25	0.94	1.76
8. Equivalent mean LIMEW							
(deflated by PCE deflator)	1.35	1.16	3.25	2.55	0.47	1.29	1.77
9. GDP per capita	2.73	1.34	3.37	2.03	1.26	1.58	2.18
Memo items							
10. CPI-U deflator less GDP deflator	-0.09	1.12	0.37	0.80	0.14	0.00	0.45
11. PCE deflator less GDP deflator	-0.32	0.10	0.39	0.19	-0.22	-0.36	-0.01
12. CPI-U deflator less PCE deflator	0.23	1.02	-0.02	0.61	0.37	0.36	0.46

Notes:
CDI: Comprehensive Disposable Income. CDI equals LIMEW less the value of household production and public individual consumption, per household.
PFI: Post Fiscal Income. PFI equals LIMEW less the value of household production, per household.
LIMEW: Levy Institute Measure of Economic Well-Being, which is income less taxes plus cash and non-cash benefits plus individual public consumption plus household production, with property income valued on an annuity basis, per household.
Equivalent median LIMEW: median LIMEW per equivalent household, i.e. after adjusting for household size and composition.
Equivalent mean LIMEW: calculated as growth of equivalent median LIMEW plus growth of mean LIMEW minus growth of median LIMEW.
In lines 1-6, the deflator is the CPI-U. GDP per capita (line 9) is deflated by the GDP deflator.

Sources:
Wolff et al. (2012), Tables 2 and 3, and own calculations. Lines 1-4 are from Table 2 of Wolff et. al. (2012). Line 5 is my calculation based on Table 3 of Wolff et al. (2012). Line 9, GDP per capita (chained 2005 dollars), is from the U.S. NIPA, Table 7.1, and the PCE and GDP deflators are from the U.S. NIPA, Table 1.1.4; downloaded on 18/05/2012 from www.bea.gov. The CPI-U (line 12), the Consumer Price Index for Urban Consumers, is from the U.S. Bureau of Labor Statistics, downloaded from www.bls.gov on12/07/2012.

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Alternatives to GDP

Thinkers as far back as Aristotle have claimed that wealth is a means to achieving objectives, such as enabling people to live happy and fulfilling lives. While there are no guarantees for happiness, economic development can nevertheless be used to achieve positive social impact that can broaden an individual's spectrum of choices and give everyone greater capacity and capability to lead fulfilling lives in the manner they see fit. Apart from social factors, there are two other areas that are essential to human well-being – a healthy environment and technological progress.

Authored by CSRI Academy Members[1]

It is no surprise that improved health, as well as reduced economic and gender inequality, can enable individuals to achieve a positive social impact. Assessments of economic development should therefore also consider social indicators such as health, economic and gender inequality in order to evaluate if increasing wealth is also enhancing societal well-being. Furthermore, healthier, more equal, and more inclusive societies are likely to be more productive economically.

Environmental pollution is harmful to human health, while climate change tends to disproportionately affect the poor. Measures of economic development should therefore account for environmental impact and sustainability. In the long run, ensuring environmental sustainability will be good for economic growth as healthier soils, cleaner seas, and living forests will produce much more than if they were degraded or polluted. Furthermore, healthy ecosystems provide a range of ecological services such as air and water filtration, the true benefits of which are not yet accounted for in existing established economic measures.

"Measures of economic development should account for environmental impact and sustainability"

Historically, technological progress has been a crucial factor in driving economic development and improving human well-being. Innovative inventions can spur economic growth. Productivity increases thanks to new technologies have also helped humanity to better meet its material needs and wants through improved agriculture and manufacturing. Technological progress has reached an unprecedented stage of advancement. The ongoing Fourth Industrial Revolution and its associated technologies such as artificial intelligence will have a significant impact on economies and societies, and potentially affect human well-being. Measures of economic development should therefore also account for technological change and its potential impacts.

Environmental issues, social impact, and technological progress are vital to people's everyday lives, and thus should be properly incorporated into measures of societal well-being and economic wealth. While GDP is the most widely used standard metric, it might not be comprehensive enough to be universal. Alternative measures to GDP attempt to expand the outlook beyond the existing standards, so that countries around the world can better track their progress and world leaders can make better decisions for their people.

Accounting for the environment

Environmental aspects of economic development indicators have been discussed widely, as sustainability concerns gain traction. There is sound economic reasoning behind exploring these. If, for example, we have an oil spill, the costs associated with cleaning it up are often counted in GDP, thus inflating GDP figures and making the oil spill look like growth. However, even putting environmental costs aside, many have argued that measuring sustainability in addition to growth is important when talking about economic development since sustainability is integral to long-term progress.

Such concerns have given rise to a slew of alternative growth measures. One group focuses entirely on environmental externalities and is chiefly represented by green GDP measures, an umbrella term that has gained considerable popularity among economists and policymakers. By factoring in the

1. More information on the CSRI Academy in "About the authors" on page 66

environmental consequences of growth and production, green GDP measures deflate overstated GDP calculations, which focus solely on capital and labor, while taking land, or in other words the environment, as fixed. Because it takes land as changeable, green GDP can help policymakers make more informed decisions regarding the economy as well as environmental regulations and standards. On the other hand, an inherent challenge is the reliable measurement and monetary valuation of changes in environmental quality. However, the importance of incorporating environmental concerns into development measures has kept green GDP popular despite such concerns.

Sustainable National Income

While there are numerous approaches to green GDP, one of the most popular ones is Sustainable National Income (SNI), an indicator that takes into account to what extent our income should be allowed to grow if we want to keep our current level of welfare.[2] Unlike GDP, not only does SNI incorporate sustainability in its income measures, but it can also be used to measure environmental degradation through a simple calculation of the difference between actual and sustainable income. However, this information comes at a cost – to be able to measure these sustainable levels, one must make assumptions. These include absolute sustainability preferences among the public and variables such as technology and employment being stable.[3] However, technological and labor changes have been very rapid in recent years.

"SNI could be used as a good supplement to GDP, especially when trying to measure whether economic growth has come at an environmental cost"

Moreover, while economists often make use of homogeneous preferences or keeping certain variables stable, such assumptions can make for an indicator that is less accurate than GDP, mainly because opinions on sustainability vary widely. Considering the lack of consensus on welfare measurement, it can be hard to pick the assumptions that will lead to the most accurate measurement. Additionally, SNI implies that there is a trade-off between production and sustainability, which is not necessarily the case. Given the current state of most economies, such a trade-off can seem logical. However, green technology glosses over this trade-off in some cases, especially when it comes to energy generation.

2. B. de Boer and R. Hueting (2004), Sustainable national income and multiple indicators for sustainable development in: OECD, Measuring sustainable development, p 39–52.
3. Ibid.

Furthermore, a major downside to SNI as a measure of sustainable production levels is its assumption that with the maximum sustainable production level considering technology, environmental functions should be available "forever."[4] Assuming that this can happen with any production level is highly optimistic, especially considering that, in any system, there is eventually an unexpected shock – none exists under perfect conditions. Nevertheless, whereas SNI might appear as more of a theoretical indicator rather than a practical one, it can be used in measuring how far away from the level of sustainable income a country is. However, without making the difference between sustainable and actual income, SNI by itself offers little usability and comparability. It could be used as a good supplement to GDP, especially when trying to measure whether economic growth has come at an environmental cost.

Genuine Progress Indicator

A second group of indicators takes into consideration both environmental and social aspects, which are neglected by GDP. A promising alternative to GDP is the Genuine Progress Indicator (GPI).[5] The GPI starts with consumption data similar to that used in GDP calculations. It then adjusts this by (1) deducting for items such as income inequality, costs of crime, environmental degradation, and loss of leisure, while (2) adding the impact of items like services from consumer durables and public infrastructure, as well as the benefits of volunteering and housework.[6]

One advantage of the GPI is that it is expressed by means of a single figure in monetary terms, and as such has the same scale as GDP. The GPI can thereby serve as a per capita measure of economic performance that can be compared across nations and regions. Taking a closer look at Figure 1,[7] which shows the GPI and GDP per capita for the USA, we can see that while GDP per capita has steadily increased since 1950, GPI per capita has remained relatively stable. This would imply that the costs of economic growth, which are not captured in GDP, have undone the benefits. Whereas GDP experienced steady growth rates, the GPI did not. As it deducts for environmental degradation, among other "costs of economic growth," the GPI will decrease the larger these deductions become. In Figure 1, we can see that these deductions have actually become so large that they neutralize the benefits of economic growth.

4. Ibid
5. Redefining Progress, 1995. "Gross production vs. genuine progress". Excerpt from the Genuine Progress Indicator: Summary of Data and Methodology. Redefining Progress, San Francisco.
6. Talberth, J., Cobb, C. W., & Slattery, N. (2007). The Genuine Progress Indicator, 2006: A tool for sustainable development. Redefining progress.
7. Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Talberth, J., Jackson, T., & Aylmer, C. (2013). Beyond GDP: Measuring and achieving global genuine progress. Ecological Economics, 93, 57-68.

One of the most cited critiques of the GPI is that it requires subjective value judgments over which items to include and how to value them.[8] Additionally, the GPI is a weak measure of sustainability as it assumes perfect substitutability among different forms of capital.[9] For instance, the depletion of natural resources can be masked by substitution of human-built capital since all items are expressed in the same unit, i.e. monetary terms. However, human-built and natural capital are in fact not interchangeable. Even if we have great human capital benefits, these can never substitute vital natural capital attributes such as, for example, the ozone layer. Thus, taking sustainability differences into account is traded off for the advantage of expression in monetary terms.

Adjusted Net Savings

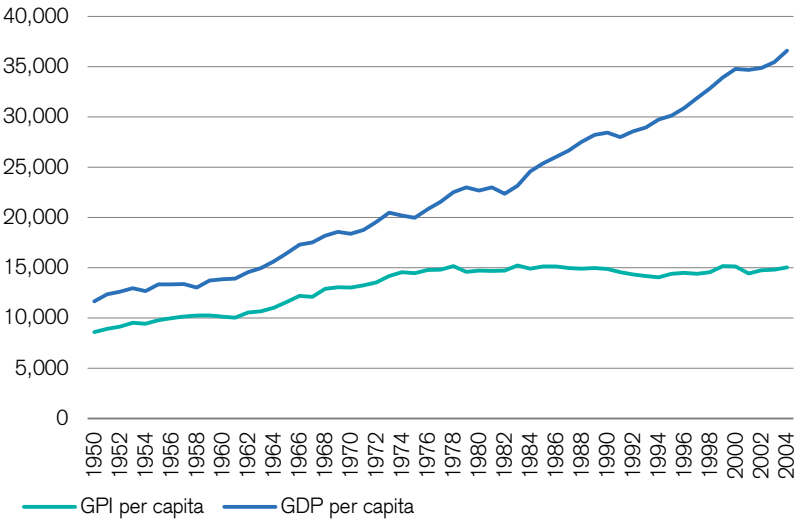
Another recognizable alternative to GDP, resulting from the vast amount of criticism over GDP's limitations concerning sustainable growth,[10] is the Adjusted Net Savings (ANS) indicator (also known as Genuine Savings), which is expressed as a percentage of Gross National Income (GNI). ANS encompasses the standard national accounting measure of gross saving, adjusted by (1) deducting the consumption of fixed capital, (2) adding current public expenditure on education, (3) deducting estimates of natural resource depletion, and (4) deducting for damages from carbon dioxide and particulate emissions.[11] The interpretation of ANS is straightforward: a negative ANS denotes that we are depleting capital stocks, whereas a positive ANS means that we are building wealth.

The ANS indicator has earned a strong recognition due to its coherence and simplicity, but also because it has been adopted to some extent by various supranational institutions, including the World Bank, the United Nations[12] and the European Union.[13]

8. Neumayer, E. (1999). The ISEW: not an Index of Sustainable Economic Welfare. Social indicators research, 48(1), 77-101.
9. Neumayer, E. (2003). Weak versus strong sustainability: exploring the limits of two opposing paradigms. Edward Elgar Publishing.
10. For example, Robert Costanza et al., "Development: Time to leave GDP behind", The Nature 505, (2014), 283–285.
11. World Bank, World Development Indicators 2007. World Bank: Washington DC; Bolt, K., Matete, M., and Clemens, M. (2002). Manual for Calculating Adjusted Net Savings. Environment Department, World Bank: Washington DC.
12. United Nations (2014). Prototype Global Sustainable Development Report. New York: United Nations Department of Economic and Social Affairs, Division for Sustainable Development, July 2014, p.81. http://sustainabledevelopment.un.org/globalsdreport.
13. It was considered potentially useful as one of the indicators for the Lisbon Agenda.
European Parliament, Policy Department, Economic and Scientific Policy (2007), "Alternative Progress Indicators to Gross Domestic Product (GDP) as a Means towards Sustainable Development, Study requested by the EU Parliament's Committee on the Environment", Public Health and Food Safety, p. 28.

Figure 1

Real GDP and GPI per capita, 1950–2004 (in 2000 USD)



Source: Talberth, J., Cobb, C. W., & Slattery, N. (2007). The Genuine Progress Indicator, 2006: A tool for sustainable development. Redefining progress

Since ANS can be used on a national, regional and global scale, and because the calculation involves corrections for human and natural capital, its employment appears to be a desired policymaking instrument for the qualitative measure of growth. Among other shortcomings, ANS suffers from the same drawback of being a weak sustainability measure just like the GPI discussed earlier, as it allows natural resources to be compensated by production and human capital.[14] Thus, despite promising efforts, the ANS indicator itself appears to be a step in the right direction, rather than a ready-made alternative for GDP.

Accounting for social factors

The most important assets of a nation are arguably its people rather than the sum of its material wealth since human beings are both the means and the ends of economic development.[15] Growing awareness of the importance of improving human welfare through development has led to various indices being created that assess human and societal well-being by considering social indicators such as health, education, economic inequality, and gender inequality. These indicators are particularly important since improved health and education, as well as reduced economic and gender inequality can enhance the range and capabilities of individuals to make choices that can enable them to live happy, fulfilling lives.

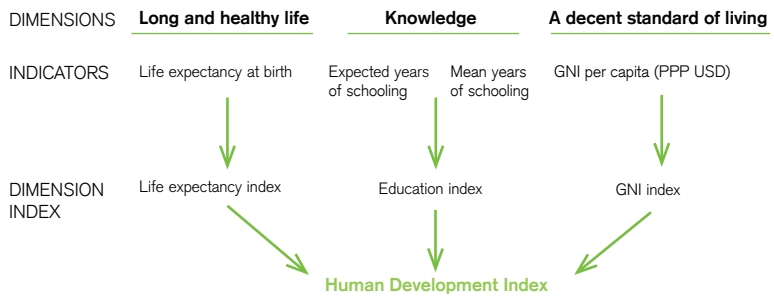
14. Hartwick, J. (1977). Intergenerational equity and the investing of rents from exhaustible resources. American Economic Review, 67, 972-974.
15. United Nations Development Programme (UNDP), Human Development Report 1990 (New York, NY: Oxford University Press), 9, available from http://hdr.undp.org/sites/default/files/reports/219/hdr_1990_en_complete_nostats.pdf, Mahbub ul Haq, Reflections on Human Development (New York, NY: Oxford University Press, 1995), 3.

There are also potential economic benefits to be gained from using national wealth to achieve social impact. For instance, research suggests that reducing gender inequality could potentially boost GDP growth. Social impact can be defined as "a significant, positive change that addresses a pressing social challenge," such as low life expectancy and educational levels, as well as economic and gender inequality.[16] Alternative indices can serve as a useful tool for policymakers by providing insights about social challenges and stimulating reflection about how economic resources could best be used to achieve the desired social impact.

16. "What is social impact?" Michigan Ross Center for Social Impact, University of Michigan, accessed 16 August 2017, http://socialimpact.umich.edu/about/what-is-social-impact.

Figure 2

Human Development Index (HDI)



Source: Human Development Report 2016 Technical Notes

Human Development Index

As an alternative to GDP, the United Nations Development Programme (UNDP) launched the Human Development Index (HDI) in 1990, which measures the development of countries not only through economic growth, but also in terms of people's capabilities, longevity, and quality of life.[17] The HDI was created to put emphasis on how people live and develop throughout their lives, and how the different levels of human development can affect macroeconomic variables important to the economic growth of a country such as GNI and GDP.

The three dimensions comprising the HDI are long and healthy life, knowledge, and a decent standard of living. The HDI is a geometric mean of normalized indices for each of the three dimensions, as shown in Figure 2. The index uses life expectancy at birth as an indicator for health since people born into healthier societies can generally expect to live longer. Expected and mean years of schooling are the indicators the HDI uses to measure how knowledgeable the society is. The third component, "a decent standard of living," is gathered from the GNI per capita. Due to its holistic approach, the HDI can stimulate discussion about why countries with similar levels of income still have varying degrees of human development.[18]

Figure 3 is a color-coded map of the world according to HDI levels. The darker the shading, the higher is the level of human development for that given country. When compared to Figure 4, a color-coded

17. Mahbub ul Haq, Reflections on Human Development, 24–25.
18. "Human Development Index," United Nations Development Programme Human Development Reports, accessed 27 August 2017, http://hdr.undp.org/en/content/human-development-index-hdi.

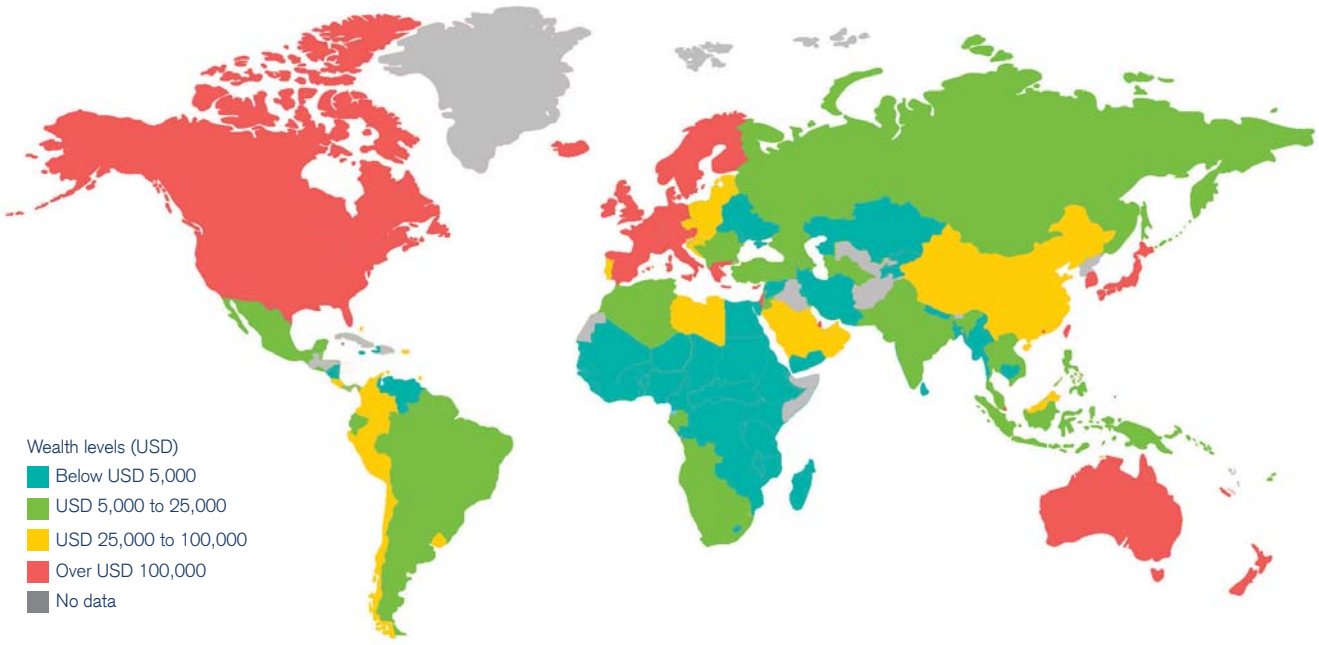
Figure 3

Global HDI Levels 2016

Source: UNDP Human Development Report 2016 (Released 21 March 2017)

Figure 4

World wealth levels 2017



Source: James Davies, Rodrigo Lluberas and Anthony Shorrocks, Credit Suisse Global Wealth Databook 2017

map of the world according to wealth, one can observe that wealthier countries tend to have higher levels of human development. This makes perfect sense, given that a decent standard of living is one of the three pillars of the HDI. It reflects the importance of material standards of living for overall well-being.[19] Meanwhile, higher levels of wealth result in more resources being available to improve health and education, thereby contributing to higher levels of human development as measured in the HDI.

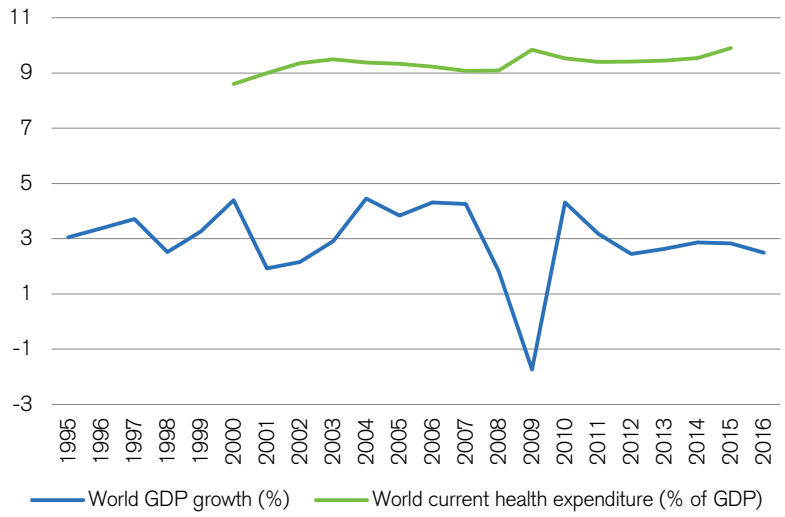
Health has an impact on, and is also influenced by human development, economic growth, and sustainability. As economic growth and advancement have slowed down over the last decade, it is of increasing importance for individuals and countries to gain competitive advantages through living healthier lives, reducing healthcare costs, increasing productivity, and raising the levels of societal well-being. Figure 5 shows the relationship between world current health expenditure and world GDP growth based on World Bank data from 2000 to 2015. The graph demonstrates that world current health expenditure as a percentage of GDP has remained at rates of between 8%–10% and trended upward over time, while the world GDP growth rate has fluctuated at around 2%–4% in the same period.

According to the World Bank, the large gap between these two indicators shows the increasing inability of GDP growth to keep up with rising health expenditure around the world. Policymakers will face the challenge of how to pay for

19. "Maximizing Healthy Life Years: Investments that Pay Off," World Economic Forum (January 2015): 4.

Figure 5

World current health expenditure (% of GDP)



Source: World Bank database

Shutterstock, Pattarika Sisombat

expanding health costs while economic growth is slowing down. Indices that provide information about average societal health levels, such as the HDI, are thus likely to become ever more relevant than before.

"A well-educated and skilled labor force is necessary for countries to diversify their economies"

Education is also critical to human and economic development. The widely adopted view is that education increases skills and knowledge and provides greater opportunities in life. Also, higher levels of education can stimulate innovation, which boosts economic productivity. A well-educated and skilled labor force is necessary for countries to diversify their economies and move up production value chains, which is crucial for prolonged economic development. GDP does not consider health indicators or educational levels. A focus on GDP alone may lead to policies that promote economic development, but that leads to increased pollution or elevated stress levels, which can all trigger the onset of non-communicable diseases (NCDs) that are long-lasting and have high treatment costs. More holistic development measures like the HDI that emphasize health and education can help policymakers strike a balance between promoting more sustainable economic growth and increasing human well-being by building up a healthier and better educated workforce.[20]

Inclusive Development Index

Despite the widespread adoption and utilization of the HDI as a holistic measure of national progress, analysts have continually attempted to redefine development in yet more meaningful and nuanced ways. These attempts often strive to quantify economic well-being in a manner that captures more relevant information than purely GDP per capita. The HDI as it was originally created has certain limitations. It does not account for the environmental impact on human well-being, nor does it consider the influence of inequality on human development. Therefore, several alternative metrics such as the Inequality-Adjusted HDI have been created to account for this shortcoming.

20. "About Human Development," United Nations Development Programme: Human Development Reports, accessed 25 April 2018, http://hdr.undp.org/en/humandev; "Maximizing Healthy Life Years: Investments that Pay Off," World Economic Forum (January 2015): 4; "Noncommunicable diseases," World Health Organization, accessed 25 April 2018, http://www.who.int/en/news-room/fact-sheets/detail/noncommunicable-diseases; "Human Development Index (HDI)," United Nations Development Programme: Human Development Reports, accessed 25 April 2018, http://hdr.undp.org/en/content/human-development-index-hdi."

In 2017, the World Economic Forum (WEF) created the Inclusive Development Index (IDI). This new metric examines economic prosperity, in the contexts of growth and development, inclusion, and intergenerational equity.[21]

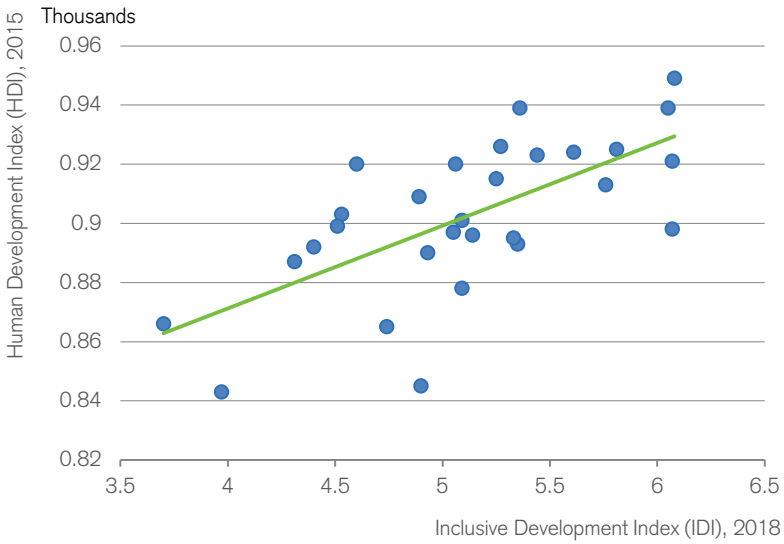
Deepening inequality as a consequence of pro-growth policies such as free trade agreements has been cited as a key cause of the recent global surge in support for populist politicians.[22] The political disruptions engendered by inequality as well as growing awareness of the economic consequences of inequality have spurred a broader focus on equity and inclusive growth, and led to the development of indices that include indicators for inequality. To evaluate the three pillars of economic prosperity, namely growth and development, inclusion, and intergenerational equity, the IDI uses a range of indicators. In addition to GDP per capita, the IDI examines 11 other indicators, including Gini measures of income and wealth inequality, dependency ratios and public debt levels to better assess an economy's overall standing.[23] The IDI is designed to better reflect society's bottom-line measure of economic progress, namely broad-based living standards. Living standards are a multidimensional phenomenon that encompasses income, employment opportunity, economic security, and quality of life. The IDI's bottom-line approach allows it to serve as a useful complement to GDP, which can be understood as a top-line metric of national economic performance.[24]

Since the IDI's varying component indicators are frequent and logical targets of policymakers, the index carries the same intuitive appeal that has long kept GDP per capita a popular indicator. The IDI aims to both provide an impetus for policymakers to make beneficial prescriptions, while simultaneously creating a practical framework within which they may do so. Figure 6 has been constructed with the most recent HDI and IDI values available, and shows that among 29 advanced economies as defined by the WEF, the IDI displays a strong correlation with the HDI.[25]

Meanwhile, Figure 7 shows a strong correlation between the IDI and GDP per capita among these same 29 developed economies. These graphs suggest that, if inclusivity is promoted, it may aid in both economic and human development. The IDI may be versatile, but its direct applicability as a tool for policymakers is ultimately limited. Like other broad measures of development, the IDI evaluates an entire economy at a given point in time, and cannot be used to evaluate the impact of any individual policy or economic project. Nevertheless, the IDI can serve as a useful alternative and complement to GDP per capita as a way of evaluating economic development.

Figure 6

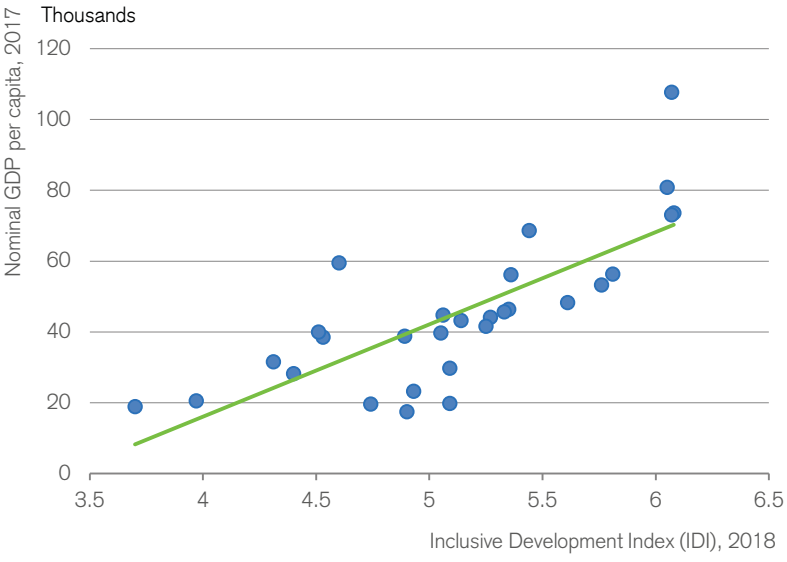
Human Development Index, 2015 vs. Inclusive Development Index, 2018



Source: "The Inclusive Development Index 2018: Summary and Data Highlights," World Economic Forum (January 2018); "Human Development Report 2016: Human Development for Everyone", UNDP, (March 2017)

Figure 7

GDP per capita (nominal, USD), 2017 vs. Inclusive Development Index, 2018

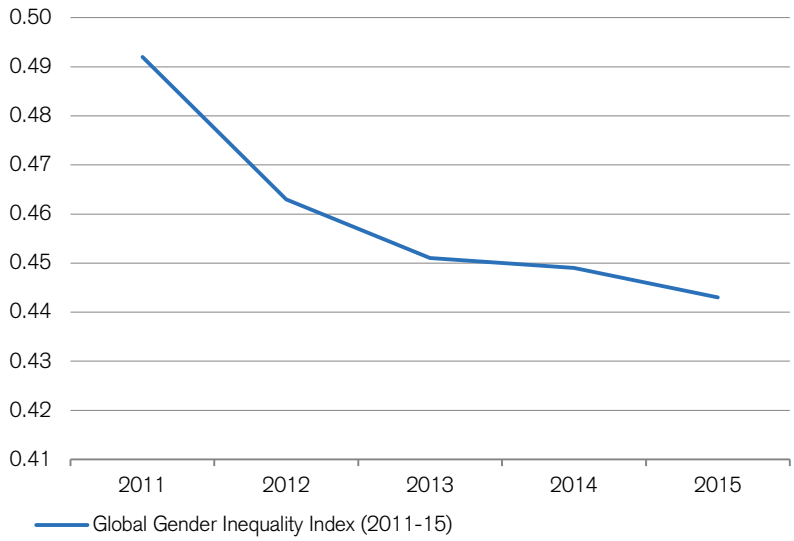


Source: "The Inclusive Development Index 2018: Summary and Data Highlights," World Economic Forum (January 2018); "World Economic Outlook Database," IMF (October 2017)

21. Alex Gray, "These are the world's most inclusive economies," World Economic Forum, 18 April 2018.
22. Zlata Rodionova, "Rising inequality behind Brexit and Donald Trump victory is top global threat for the next decade, says WEF," Independent, 11 January 2017, http://www.independent.co.uk/news/business/news/wealth-gap-global-income-inequality-brexit-donald-trump-victory-threat-a7521286.html.
23. "The Inclusive Growth and Development Report 2017," World Economic Forum, accessed 27 August 2017, https://www.weforum.org/reports/the-inclusive-growth-and-development-report-2017; "The Inclusive Development Index 2018: Summary and Data Highlights," World Economic Forum (January 2018): 2.
24. "The Inclusive Development Index 2018: Summary and Data Highlights," World Economic Forum (January 2018): 1, 2, 6.
25. Advanced economies defined by the WEF arranged according to their overall 2018 IDI score from highest to lowest: Norway, Iceland, Luxembourg, Switzerland, Denmark, Sweden, Netherlands, Ireland, Australia, Austria, Finland, Germany, New Zealand, Belgium, Czech Republic, Korea Rep., Canada, France, Slovenia, Slovak Republic, United Kingdom, Estonia, United States, Japan, Israel, Spain, Italy, Portugal and Greece (source: "The Inclusive Development Index 2018: Summary and Data Highlights," World Economic Forum, January 2018, page 3).

Figure 8

Global Gender Inequality Index (2011–15)



Source: UNDP Human Development Reports

In 2010, the United Nations Development Programme introduced the Gender Inequality Index (GII) to address the lack of attention to the issue and to quantify the human development costs caused by gender inequality. The GII evaluates gender inequality in three aspects of human development – reproductive health, empowerment, and economic status. The higher the GII value, the greater the disparity between females and males, and the higher the loss to human development. The GII sheds light on the position of women in 159 countries.[27]

"Multiple studies have shown that gender inequality comes with huge economic costs"

The WEF has pointed out that the choice of which metric to use to evaluate the economy can influence policy priorities and objectives. The traditional focus on GDP as the primary measure of economic prosperity tended to influence political and business leaders to emphasize macroeconomic and financial stability policies, which influence the overall level of economic activity. If widely adopted, the IDI may help nudge policymakers and the business world toward a paradigm of more inclusive growth by drawing attention and efforts towards issues such as the strength and equity of institutions and stimulate initiatives and policies in such areas as skills development, labor markets, competition and rents, investor and corporate governance, social protection, infrastructure, and basic services. These areas are essential in order to increase the breadth of participation in economic growth, thereby helping to make economies more inclusive.[26]

Gender Inequality Index

Historically, the issue of gender inequality and its impact on development has often been overlooked as women were accorded a lower socio-economic status in many societies. Despite the remarkable improvement in stature achieved by women in the 21st century, many women continue to be discriminated against in the spheres of health, politics and education. The cost of gender inequality to development is also not adequately highlighted. For example, indices such as the HDI and the IDI – even though the latter includes measures on wealth and income inequality – do not include any indicators for gender inequality and its impact on development outcomes.

26. "The Inclusive Development Index 2018: Summary and Data Highlights," World Economic Forum (January 2018): 1, 2.

The GII component indicators highlight areas in need of critical policy intervention, and could stimulate proactive thinking and public policy to overcome the systemic disadvantages that women face. Multiple studies have shown that gender inequality comes with huge economic costs. The OECD, for example, suggests that up to 12% could be added to GDP by 2030, if the gender gap in labor force participation is reduced.[28] The 2018 Credit Suisse Research Institute Davos Edition report entitled "Eradicating Extreme Poverty" meanwhile synthesized evidence which shows that investing in women's health, education, and empowerment can significantly stimulate their multiple contributions to the economy.

The report for instance cited research that found that when women earn more and account for a larger share of household income, a greater share of household spending is directed toward the health of the family, which has a positive impact on the economy.[29] Highlighting increases in economic potential due to reductions in gender inequality could stimulate discourse on whether or not societies can afford to marginalize their female populations, and eventually even facilitate the empowerment of females.

27. "Technical notes," United Nations Development Programme: Human Development Reports, accessed 9 September 2017, http://hdr.undp.org/sites/default/files/hdr2016_technical_notes_0.pdf.
28. Mari Kiviniemi, "Why a push for gender equality makes sound economic sense," OECD, accessed 9 September 2017, http://www.oecd.org/gender/push-gender-equality-economic-sense.htm.
29. Dr. David E. Bloom, Dr. Michael Kuhn, and Dr. Klaus Prettner, "Escaping poverty: Investing in women's human capital" in Eradicating Extreme Poverty, (Zurich: Credit Suisse Research Institute, 2018), 6, accessed 18 April 2018, http://publications.credit-suisse.com/tasks/render/file/index.cfm?fileid=CBDD8A5D-F081-BFB1-1A0BF3D-649FAB94F.

The use of the GII as one additional key index for decision-making would enhance the visibility of gender inequality and its cost on society. The GII could be particularly useful to highlight the human development losses in societies where women are still significantly marginalized due to historic societal norms and prejudices, and where, historically, there may have been a lack of policies to reduce gender inequality. Figure 8 shows that since the GII was first published in 2010, gender inequality has declined globally on average. The rate at which the gender gap is closing, however, seems to be slowing down.

The world still has a long way to go to end gender inequality and the GII can continue to guide policymakers by providing insights about the gender gap in key areas of human development such as health and education. Even though the GII has its limitations and it alone cannot be the sole replacement for GDP as a key index of development, there should be continued research on how to better account for the costs of gender inequality on social welfare and integrate it into decision-making and policymaking processes.[30]

Happiness Index

The modern critique of economic growth was eloquently expressed in Robert F. Kennedy's famous speech: "Gross National Product counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage… It measures neither our wit nor our courage, neither our wisdom nor our learning…" The speech taps into the popular notion that money is happiness in the abstract (as Schopenhauer put it), and that the breathless chase for bigger GDP brings a plethora of negative effects. A happiness index as an alternative to economic output is not a new idea – at the end of the 18th century, the Enlightenment philosopher Jeremy Bentham developed a system that estimates the pleasure in the populace caused by political actions. However, the recent Global Financial Crisis created new impetus to end the obsession with GDP growth and seek out other measures of progress.

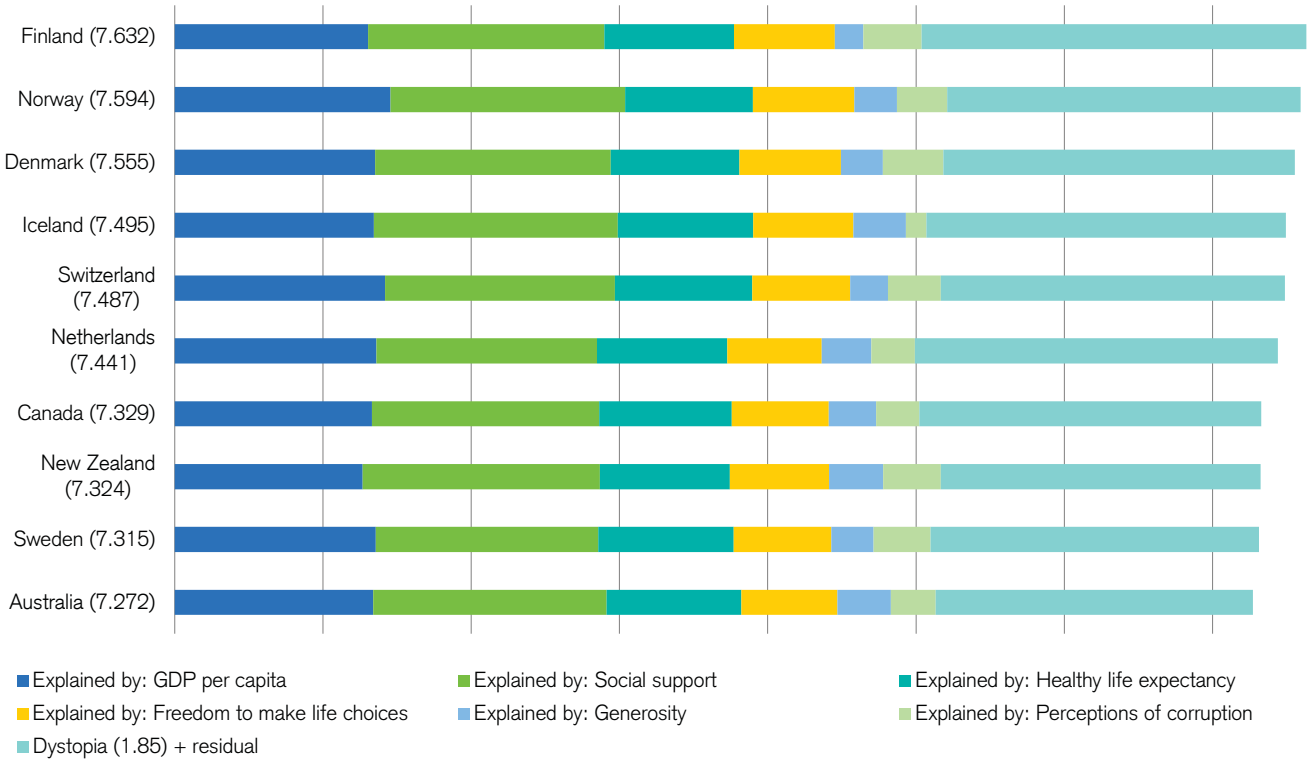
The World Happiness Report, first published in 2012 by independent experts,[31] has spearheaded a movement to accept happiness and well-being as important measures of social progress. In 2016, the then head of the United Nations Development Programme, Helen Clark, excoriated the "tyranny of GDP" and stressed the importance of sustainable growth. The World Happiness Report's international happiness ranking is created through surveys in over 150 countries that ask 3,000 respondents per country (1,000 for each of three consecutive years) to evaluate their current lives on a scale from 0 to 10, with ten standing for best possible life and zero for worst possible.

30. "Gender Inequality Index (GII)," United Nations Development Programme: Human Development Reports, accessed 25 April 2018, http://hdr.undp.org/en/content/gender-inequality-index-gii.

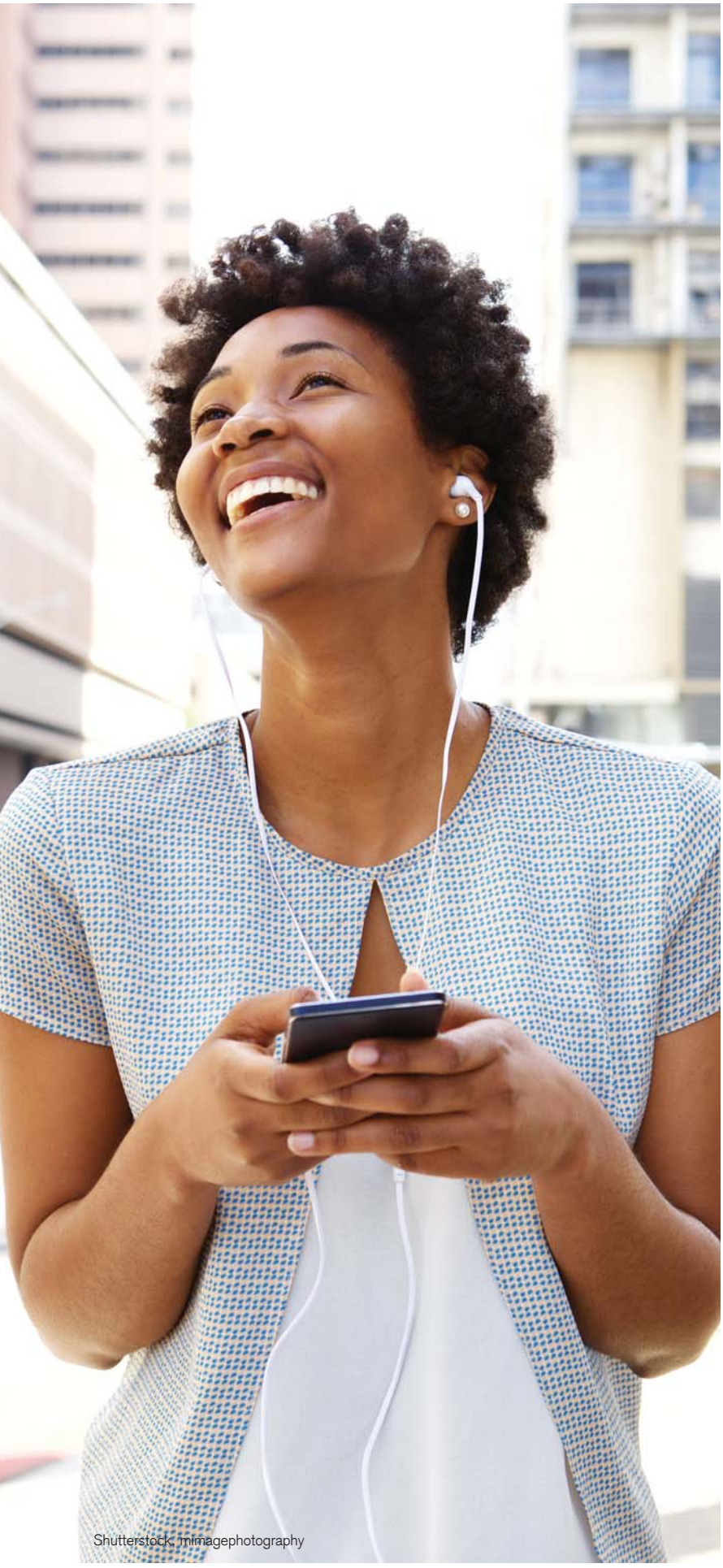
31. "World Happiness Report 2017," World Happiness Report, accessed 27 August 2017, http://worldhappiness.report/ed/2017/.

Figure 9

Top 10 happiest countries in the world, 2015–17



Source: Helliwell, J., Layard, R., & Sachs, J. (2018). World Happiness Report 2018, New York: Sustainable Development Solutions Network



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The life evaluation survey is employed because it consistently provides stable, informative results across countries and more fully captures life circumstances than alternative measures. Figure 9 shows the happiest countries according to the report's results. Surprisingly or not, the happiest countries are not the economic or political locomotives of the world. For example, China is ranked number 86.

"GDP growth does provide a boost to happiness, but has to be complemented with other social factors"

The World Happiness Report posits that differences in happiness among countries are largely (about 75%) explained by six variables: GDP per capita, life expectancy, trust (in business and government), social support, perceived independence to make life decisions, and generosity. According to Figure 9, GDP per capita, social support, and life expectancy are the most important factors, proving that GDP growth (on average) does provide a boost to happiness, but has to be complemented with other social factors. The top countries in the global happiness ranking score high on all six factors. China, on the other hand, presents a cautionary example: despite a startling increase in GDP, Chinese citizens are no happier than they were 25 years ago. This is why, rather than ignoring GDP growth or obsessing over it, it is best to supplement it with other indicators that will provide a better overall picture and more insight for policymakers. In addition, the index uses first-hand data from people living in the countries, which should add value to traditional economic measures focused on officially reported data.

The Human Development Index, the Inclusive Development Index and the Gender Inequality Index can serve as useful complements to GDP as they focus very much on current societal issues such as wealth and gender inequality, and hence allow policymakers to have a more distinct and inclusive picture of an economy. The population's happiness is a way to incorporate the earlier-examined measures including environmental and social indices by taking the first-hand data from people living in the countries and making sense of it in addition to traditional economic measures. Development plans should consequently include policies that not only boost GDP, but also improve health and education, increase economic inclusion, and promote gender and wealth equality in order to enhance people's capability and capacity to live happy, fulfilling lives.

Accounting for technological development

The Fourth Industrial Revolution[32] is characterized by technology's interference in sectors, industries, sub-industries, and products and services across many countries. Ultimately, it is expected to be a seamless fusion of physical, digital and biological technologies, such as artificial intelligence, robotics, nanotechnology, the Internet of Things, autonomous vehicles, 3-D printing, energy storage, blockchain, and quantum computing. What is so special about these technologies is that the pace of change is exponential. Even when compared to the previous industrial revolutions, the Fourth Industrial Revolution is exceptionally evolving and causing one-way disruption. Not only do business leaders have to comprehend the changing environment at the micro level, but also country leaders and policymakers must take the disruption into account.

Digitalization and freemiums

The Fourth Industrial Revolution has been most aptly embodied in the sweeping rise of digitization and "freemium" services (free services with the option of paying a premium for additional features) that have disrupted long-stagnant industries across the globe. While definitions abound, disruptions are best characterized as processes where unestablished upstarts successfully challenge incumbents by taking advantage of either low-end or new-market footholds that are untouched or underutilized by current market leaders.[33]

"There are four main causes for mismeasurement of the true economic impact of disruptive technologies"

By creating new technologies and using old ones in new ways, numerous disruptors have emerged to date. Consequently, the disrupting mavericks of this world are a challenge not only for regulators and policymakers, but also for anyone interested in gauging the true level of economic activity.[34]

There are four main causes for mismeasurement of the true economic impact of disruptive technologies as assessed by traditional GDP measurement schemes. First is the conversion of paid content into freemium consumption. In the past decade, companies such as Google have significantly expanded the commons by making previously paid-for content available for free.[35] On any given day, virtually everyone in developed countries has free access to information and content that two decades ago would have been cost-prohibitive to produce on an ad-hoc and tailored basis.[36] As we consume more and more information and content online for free, industries such as the news media continue to chalk up casualties and drag down GDP as businesses go under.

Elsewhere, disruptive companies have made similar expansions in the quantity of goods and services provided for a set price. For instance, a mere decade ago, a consumer could expect to buy a dozen songs for ten dollars and, if lucky, receive a hidden bonus track. Today, the same amount can provide access to more than 30 million songs, consumable at leisure.[37] Dilemmas of choice aside, a greater variety should result in an increased consumer surplus, which today is either left uncounted or marked as a decrease in GDP due to less expenditure per category of consumption.

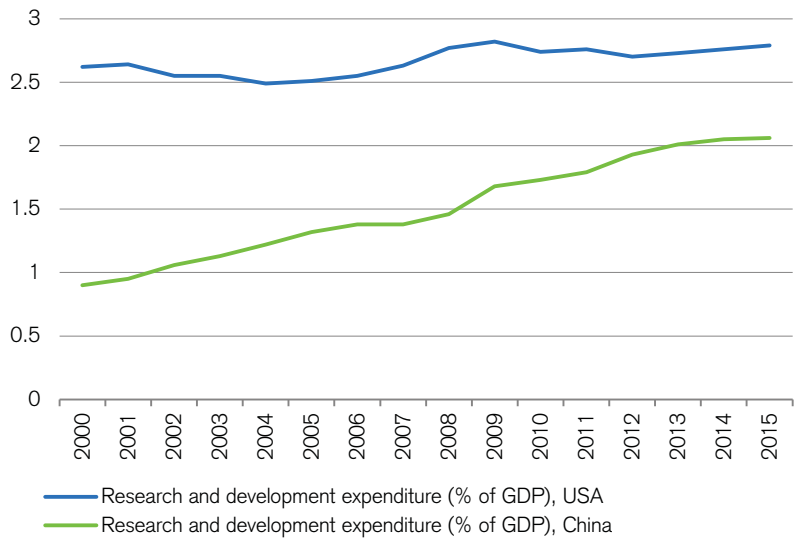
"As a corollary of increased quality, disruptors also enhance the productive efficiency within their sectors"

In addition to quantity, disruptive technologies also modulate the quality of services and goods consumed.[38] For example, social-media-generated ratings and the minute-to-market accuracy of modern trading platforms provide everyday consumers a luxury of ease and quality that could not have been purchased for any price half a century ago. As with free services and household work, greatly valued increases in quantity hold no sway over GDP measures. As a corollary of increased quality, disruptors also enhance the productive efficiency within their sectors. New technology companies have ousted traditional incumbents by establishing platforms that transform peers into providers and eliminate middle tiers in distribution and production. Since their emergence, peer-to-provider and sharing-economy services have significantly increased the volume of transactions that take place in their targeted industries. However, the aggregate value of these engagements is likely to be severely undercounted due to the elimination of middlemen and other efficiency benefits.

32. www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond.
33. "What Is Disruptive Innovation?", Clayton M. Christensen, Michael E. Raynor, Rory McDonald.
34. https://www.weforum.org/agenda/2016/01/is-technological-change-creating-a-new-global-economy.
35. Erik Brynjolfsson and Avi Gannamaneni, "Measuring Changes in Consumer Surplus in the Digital Economy," MIT IDE Research Project, 2016.
36. Peter Marsh (2012). The New Industrial Revolution. Yale University Press: 57.
37. https://press.spotify.com/us/about.
38. https://www.sitra.fi/en/articles/challenges-measuring-digital-economy.

Figure 10

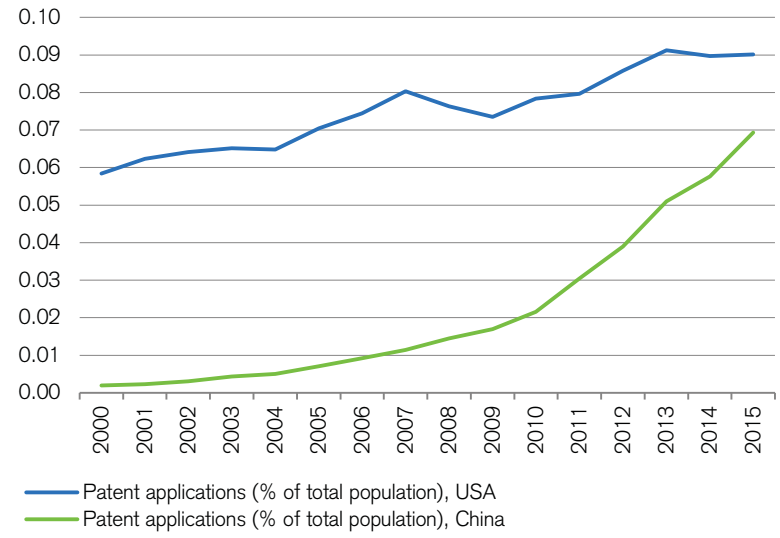
Research and development expenditure (% of GDP), USA and China



Source: The World Bank Group Data, Research and Development Expenditure (% of GDP), Creative Commons Attribution 4.0 International License (CC-BY 4.0)

Figure 11

Patent application (% of total population), USA and China



Source: The World Bank Group Data, Patent Applications (Residents), Creative Commons Attribution 4.0 International License (CC-BY 4.0)

Innovation measures

To grasp the impact of technology, it is important to find ways to incorporate the innovation, including disruption, aspect into measuring a country's economic activity and growth potential. The purpose of adding complementary technology metrics to established metrics like GDP is to increase the understanding of a country's economic prospects.

One way to accomplish this is to turn to standardized innovation indices that span over the last few decades. The indices to focus on include Research and Development (R&D) Expenditures and Patent Applications by Residents.[39] Expenditure on research and development is undertaken systematically to increase knowledge – including knowledge of humanity, culture and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development. Figure 10 shows the R&D expenditure trends for the USA and China. Patent applications are worldwide applications filed through the Patent Cooperation Treaty procedure or with a national patent office to receive exclusive rights for an invention, i.e. a product or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection of an invention and exclusive rights to the owner of the patent for a limited period, generally 20 years. Figure 11 shows the patent filing trends for the USA and China.

China has experienced a steady upward trend in both metrics and the USA has been consistent over time. Interestingly enough, especially in China, the financial crisis of 2008 did not affect either of the measures significantly, which means that these measures might not be driven by the same forces as traditional economic measures are and might thus have valuable alternative explanatory power. Notably, China is behind the USA in terms of total and per capita GDP, but patent filings as a ratio of total population is gradually getting close to the US figure. Since intellectual property is supposed to have long-term consequences given the 20-year exclusivity period, this ratio might also add alternative explanatory power to traditional measures. For example, if China has more patents per capita than the USA does, this ratio can help solidify the country's longer-term growth expectations estimated by economists.

The logic behind the innovation indices is that countries with high proportions of R&D expenditure as a percentage of GDP and relatively large numbers of patent filings are deemed to be the most technologically fit for innovation. In fact, they should be innovation leaders since such countries are at the frontier of the Fourth Industrial Revolution given their lead in R&D spending and

39. www.theglobaleconomy.com/summary_statistics.php; www.databank.worldbank.org/data/reports.aspx?-source=2&series=IP.PAT.RESD&country; www.data.oecd.org/rd/gross-domestic-spending-on-r-d.htm; www.data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?page.

patent applications. More importantly, countries that have growth trends in both measures are expected to have a superior transformational fit compared to other countries. China proves the point: outstanding growth in patent filings supported by a steady upward trend in R&D. One could assume that China is well positioned for innovative and disruptive technology, being both proactive about leading in-house innovations and reactive to the world's new technologies.

How do the two metrics add insight to traditional measures and what does this imply going forward? First, these metrics can explain the rate of GDP growth: if we correlate real GDP growth in the USA from 2000 to 2015 to the growth in patent filings, the correlation is equal to around 0.97. Second, the metrics are not only relative, but also absolute. Thus we can expect those countries with the highest number of patent filings to be the most technologically advanced and well positioned to address innovation. Finally, economists can build expectations about the economic growth of countries by extrapolating innovation indices with the idea that the most technologically advanced countries are expected to lead the way into the Fourth Industrial Revolution.

On the other hand, this idea is equivalent to saying that the most technologically advanced countries are expected to advance further, while the least-advanced countries are expected to stay where they are. Therefore, this theory of "the rich get richer and the poor get poorer" has its weaknesses as it does not give enough insight into a country's "hidden" potential, but instead builds on the existing history of innovation.

"Equity" as an alternative measure to GDP

As GDP represents the total market value of all goods and services produced in a country, it is almost an approximation of annual national income,[40] and financiers could be drawn to treat a country like a company, examining its financials and evaluating its financial health. This experimental approach[41] translates into the well-known balance sheet equation where assets equal liabilities plus shareholder equity. However, translations of this equation into a national "balance sheet" are insufficient because governmental equivalents of a balance sheet do not reflect any of the accumulated non-governmental assets held by the public. The Inclusive Wealth Report from the United Nations University, first published in 2012,[42] offers a starting point in constructing a meaningful alternative to GDP using traditional corporate finance methods. The equation for national equity constructed in the following paragraph is an easy-to-calculate version, allowing for separation of objective and subjective measures in order to demonstrate an alternative measure to GDP.

40. www.economist.com/node/21557732.
41. documents.worldbank.org/curated/en/411171468741363762/pdf/multi-page.pdf or www.economist.com/blogs/freeexchange/2012/07/national-balance-sheets.
42. https://digitallibrary.un.org/record/784798?ln=en.

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Past research[43] has separated national fixed assets into natural, produced, and human capital, including governmental and non-governmental assets. By combining measures of household net worth and government net worth, the balance sheet equation can be transformed and most information used in past research can be inferred,[44] yielding the equation for national equity. The following reasoning applies:

Household Net Worth + Governmental Net Worth + Human Capital + Intangibles = National Equity.

Household net worth includes all ownership of corporate and non-corporate equities (non-profit organizations and households) minus liabilities. Government net worth[45] is the total value of government assets including land rights and associated resources minus all government liabilities. Theoretically, this means that household net worth and government net worth together sum up the ownership of all companies as well as natural resources and infrastructure. A simple objective measure used for human capital is the sum of educational and vocational training expenditure in a country during a period of time. For example, this period could be a rolling 35 years, indicating the number of years a person works from the age of 25 to 60. This assumes human capital fully depreciates with workers upon retirement. Therefore, the dollar value of human capital at any point in time is the number of dollars spent on education and training of active workers.

"Financiers could be drawn to treat a country like a company, examining its financials and evaluating its financial health"

Intangibles is a variable where measures can be included to fit different purposes such as social-impact factors (e.g. pollution, crime) or gauges of political power (e.g. access to foreign markets, sanctions). It can also adjust for the quality of assets like infrastructure, using a construct based on the infrastructure ratings in the Logistics Performance Index (LPI).[46]

43. documents.worldbank.org/curated/en/411171468741363762/pdf/multi-page.pdf or www.economist.com/blogs/freeexchange/2012/07/national-balance-sheets.
44. Namely Produced and Natural Capital. Natural Resources are likely to be understated, except for in depreciation calculations. Thus, this measure could be approved upon, but it would increase the difficulty in calculation.
45. This is a measure of all governmental wealth, meaning in some nations state/local net worth will need to be included. The USA provides all relevant numbers quarterly, in an aggregated form via their Financial Accounts of the United States "Flow of Funds: Balance Sheets, and Integrated Macroeconomic Accounts", the Q1 2017 publication can be found at www.federalreserve.gov/releases/z1/current/z1.pdf.
46. lpi.worldbank.org/international/global.

Intangibles can be calculated as a sum product of relevant standardized factors weighted by betas (βs) to penalize or reward factors in a nation's financial health.

Making a few changes to the well-known corporate finance balance sheet equation will thus result in a figure for national equity, representing a nation's assets minus the money it borrows from foreigners, and can be extended further to include human capital and many intangible aspects of a nation's total equity. While this approach is experimental and does not have widespread research coverage, it can be used as a complement to GDP to provide more insight, especially when it comes to human capital and intangibles.

The ultimate source of growth in human history, from the invention of the wheel to the invention of the internet, has always been innovation. Today, the innovation pipeline is full of promising disruptive technologies supposedly destined to redefine businesses in many industries around the developed and developing world. The alternative measures examined in this section spring from this latest school of thought and add to traditional measures like GDP. A nation's transformational fit and its wealth are useful to better understand the economic prospects of a given country. Transformational fit measures can add insight into innovation trends and their robustness. A country's wealth is another way to understand its economic well-being.

The challenge

The main challenge with all the indicators discussed in this chapter is a technical one, as they require the quantification of environmental, social and technological factors in monetary terms. One can argue that, the more these alternatives find their way into the public space and the more backing they receive from policymakers, the more resources will flow into further developing and refining them. This would be especially important in developing countries, for which data is scarce.

None of the discussed measures is a perfect alternative measure of economic progress. However, it stands to reason that even the slightest improvement or addition to measuring economic welfare is better than merely measuring the quantity of economic activity. After all, as John Maynard Keynes once put it, "it is better to be roughly right than precisely wrong." ■

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How GDP fails the environment and how to fix it

A growing economy has become synonymous with prosperity. Gross domestic product, or more specifically GDP growth, has become by far the most influential indicator of economic health and the fixation of national debate and policymaking. As GDP was developed in the 20th century, however, it does not fully account for issues critical to prosperity in the 21st century such as a stable climate. We believe the way we deal with environmental and social issues will determine prosperity over the coming years. Given GDP's fundamental limitations, is now the time to find a new system or to adapt GDP to take full advantage of opportunities and deal with the challenges we face today?

Pooran Desai OBE HonFRIBA, co-founder of Bioregional Development Group
Nicholas Schoon, senior researcher and writer at Bioregional Development Group

Economic prosperity depends on the living fabric of planet earth – the biosphere. Climate change is one sign of the damage our economy is doing to it.

"We see storms, we see droughts…At night you see cities lit up in populated parts of the world. It's quite amazing to see how many people actually live down there and how much of an effect they are having on the environment and the land we live on. It is a cause for concern. Since my first flight in 1990 and this flight, I've seen changes in what comes out of some of the rivers, … in land uses… we are losing lots and lots of trees. There is smoke and dust in wider spread areas than we have seen before…We have to be very careful how we treat this good Earth we live on." (NASA astronaut Commander Frank Culbertson.[1])

Planet earth is unique as far as we know. It is the only planet on which we have identified life. It is a rich planet with forests, grasslands, rivers and oceans teeming with life. Humans can work with nature to increase its productivity through good stewardship such as sustainable forestry[2], combating erosion and degradation of soils to avoid disasters such as the Dust Bowl in the USA in the 1930s[3] or taking steps to replenish fish stocks.[4] Looking back, without the bounty of planet earth, it is hard to imagine how the human species, civilization and the modern economy could have emerged. Going forward, particularly with a growing human population, global society cannot survive without a similarly bountiful planet. If we could look down from space, like Commander Culbertson, we would see with our own eyes that, over a very short period of time, we have been destroying the planet's biosphere – on which our prosperity depends. Spaceship Earth is a long-standing analogy that can help us better understand the challenge to which we must rise.[5]

Of all the signs of damage to the biosphere, climate change is the one that has come to dominate public discourse. That gases can trap heat in the atmosphere and affect climate was first postulated almost 200 years ago by French physicist Jean-Baptiste Joseph Fourier. Since the industrial revolution, the concentrations of carbon dioxide have increased from about 280 parts per million (ppm) to more than 400 ppm, raising global temperatures by roughly one degree Celsius so far.[6]

"Humans can work with nature to increase its productivity through good stewardship"

The year 2016 was the world's hottest and 2015, 2016 and 2017 were the three hottest years on record stretching back more than a century.[7] Worryingly, carbon dioxide concentration in the atmosphere is still accelerating.[8] The 2017 floods in Houston and hurricanes Harvey and Irma are just a few examples in the growing number of extreme weather events from heat

1. https://www.theguardian.com/science/2001/aug/31/spaceexploration.
2. Bringing back the forests, Proceedings of an International Conference 7–10 October 2002, Kuala Lumpur, Malaysia.
3. https://en.wikipedia.org/wiki/Dust_Bowl.
4. http://www.fao.org/newsroom/common/ecg/1000505/en/stocks.pdf.
5. Buckminster Fuller (1968), Operating Manual for Spaceship Earth, Lars Muller Publishers.
6. https://scripps.ucsd.edu/programs/keelingcurve/ and https://public.wmo.int/en/media/press-release/wmo-confirms-2017-among-three-warmest-years-record.
7. https://public.wmo.int/en; https://www.theguardian.com/environment/2017/jan/18/2016-hottest-year-ever-recorded-and-scientists-say-human-activity-to-blame.
8. National Oceanic and Atmospheric Administration, March 10, 2017. Carbon dioxide levels rose at record pace for second straight year. http://www.noaa.gov/news/carbon-dioxide-levels-rose-at-record-pace-for-2nd-straight-year.

waves to floods that are predicted by climate models. Some experts even implicate climate change as a contributing factor in the wars in Darfur[9] and Syria.[10] Whether the links between climate change and war can be proven is not so much the point – it seems obvious that any environmental stress carries with it an increased probability of conflict. The potential of climate change to destabilize every human and economic system has led many observers to describe climate change as the greatest threat that humanity has ever faced. For example, in May last year, UN Secretary-General António Guterres said, "Countries and communities everywhere are facing pressures that are being exacerbated by megatrends…but one overriding megatrend is far and away at the top of that list – climate change."[11]

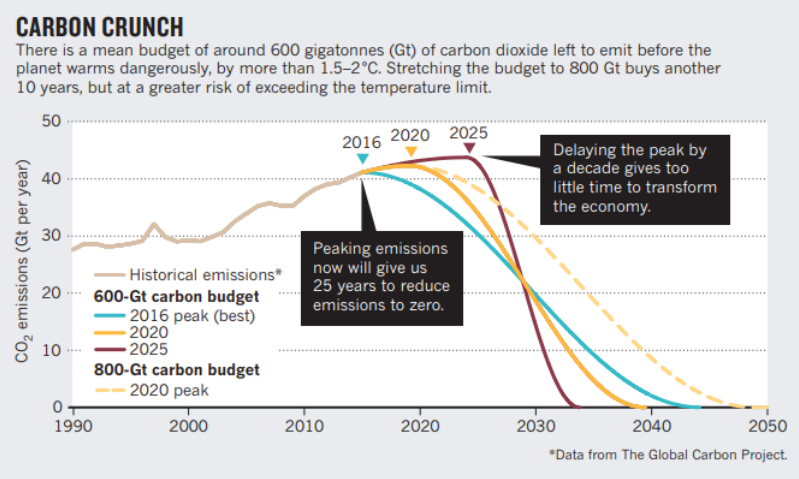
The threat of climate change is not going unheeded, though the urgency of the situation is perhaps still not widely appreciated. It has resulted in the landmark Paris Climate Agreement (notwithstanding the USA's stated intent to withdraw from the agreement), when the world's nations committed to "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels." As we have seen, temperatures have already risen by 1 °C. Best estimates are that humanity can only afford to release a further 150–1,050 gigatons (a gigaton is equivalent to a billion metric tons[12]) of carbon dioxide – our carbon budget – which would last around 4–25 years at current emission rates.[13]

"One overriding megatrend is far and away at the top of the list – climate change"

The large range in the carbon budget is due to uncertainty about how the planet will respond to further carbon emissions, given, for example, the possibility of feedback effects such as the drying of forests leading to more forest fires accelerating further carbon emissions. To achieve a smooth trajectory to a "climate stable" future, Christina Figueres, former Executive Secretary of the UN Framework Convention on Climate Change (UNFCCC), working with leading scientists, warned in 2017 that carbon dioxide emissions need to peak by 2020 and fall rapidly – meaning that we have less than "three years to safeguard our climate."[14]

Figure 1

The Carbon Crunch



Source: Reprinted by permission from Nature: Three Years to Safeguard our Climate, Figueres C. et al, 28 June 2017, copyright Nature 2017

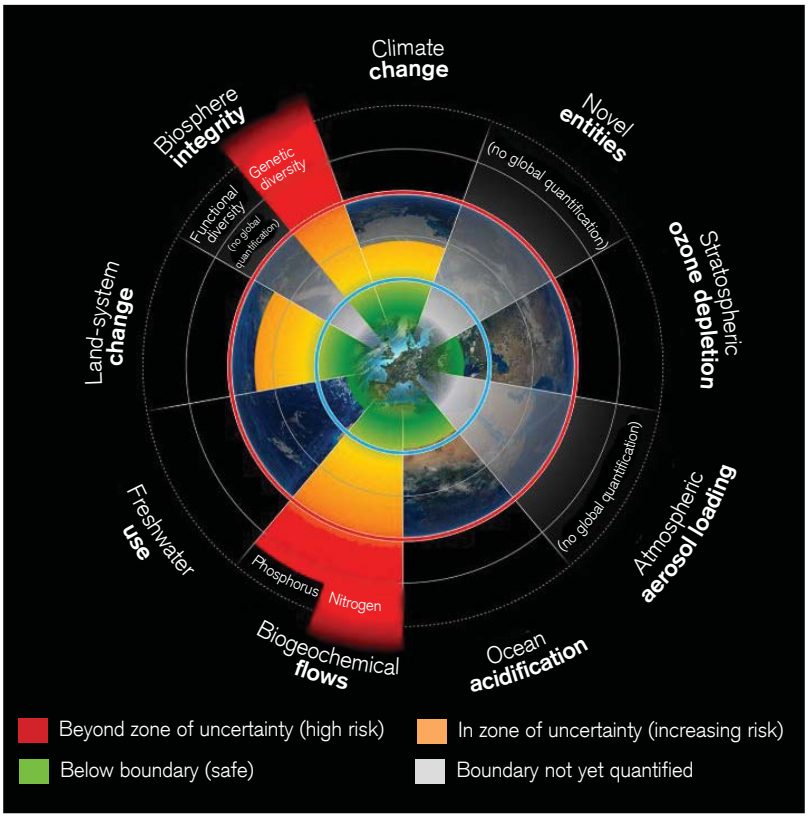
Climate change is just one outcome of how we treat the planet – and how our economy relates to the biosphere. Scientists have described nine "planetary boundaries" relating to global-scale natural systems that are being disrupted by humanity and are important for human life and continued prosperity. In 2009, led by Professor Johan Rockström from the Stockholm Resilience Centre, a group of scientists proposed a framework to define a "safe operating space for humanity." According to the group, once human activity has passed certain thresholds or tipping points, there is a risk of "irreversible and abrupt environmental change." The group identified nine such "planetary life support systems" and threats to them: climate change, novel entities (e.g. persistent synthetic chemicals), stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, biogeochemical flows (nitrogen and phosphorus), freshwater use, land-system change and biosphere integrity (including genetic diversity). Their 2015 estimate is that four of the nine planetary boundaries, including climate change and biosphere integrity, have already been crossed.[15]

Analysis of planetary boundaries clearly shows the severity and urgency of the situation. It is hard to exaggerate the implications. In this light, how does GDP shape up as an indicator of progress toward prosperity?

9. https://www.theguardian.com/environment/2007/jun/23/sudan.climatechange.
10. https://www.scientificamerican.com/article/ominous-story-of-syria-climate-refugees.
11. http://www.un.org/sustainabledevelopment/blog/2017/05/secretary-generals-climate-remarks-at-nyu-stern.
12. "Tons" in this chapter refer to metric tons.
13. Center for International Climate Research www.go.nature.com/2rytztf.
14. Christina Figueres et al (2017), Three years to safeguard our climate'. Nature https://www.nature.com/news/three-years-to-safeguard-our-climate-1.22201.
15. Steffen et al, 2015. Planetary boundaries: Guiding human development on a changing planet. Science Vol 347 no. 6223.

Figure 2

Nine proposed planetary boundaries defining a safe operating space for humanity



Source: The Stockholm Resilience Centre

GDP is out-of-step with the natural systems that determine our prosperity

GDP is the backbone of managing our consumer society. It is a monetary measure of the market value of all final goods and services produced in a period. It includes all the goods and services that make life livable – e.g. food, shelter, clothing, and luxuries such as fashion and leisure, and the "defensive expenditures" that are required to deal with society's output of "bads" – e.g. road accidents, fires and environmental damage. GDP is not a simple, scientific or "pure" number. The measurement of GDP has become complex and includes adjustments such as "hedonic pricing" to reflect changes in the quality of consumer goods.[16]

Environmental factors do have an impact on our economy and hence are reflected to some extent in GDP – environmental regulations control certain means of production (e.g. pollution emissions standards), natural factors affect productivity (e.g. climate affects crop yields), subsidies impact the scope and size of markets (e.g. for renewable energy), personal choices impact spending (e.g. choosing organic food or foregoing purchases for environmental reasons) and companies may voluntarily adopt ethical practices (i.e. corporate social responsibility, which goes beyond regulation). But any integration of environmental factors in GDP is not intentional, systematic or comprehensive. If the environment is important for prosperity, GDP has a number of problems as an effective indicator of progress. Worse still, we believe GDP is often at direct odds with environmental imperatives. The most obvious illustration is that the oil and gas exploration and production industry – a big contributor to climate change – also makes a very large direct contribution to GDP (around 5% of global GDP) and indirectly supports much of the consumer economy.[17]

16. Diane Coyle, GDP. A brief but affectionate history. Princeton University Press, 2014.

"Worse still, we believe GDP is often at direct odds with environmental imperatives"

A study by Trucost (now part of S&P Group) identified USD 7.3 trillion of unpriced natural capital costs, equating to 13% of global economic output in 2009. The majority of unpriced natural capital costs were from greenhouse gas emissions (38%), followed by water use (25%); land use (24%); air pollution (7%); land and water pollution (5%); and waste (1%). In fact, so far off track are we in our relationship to earth systems, that the study claims that many of the primary production and primary processing sectors around the world would not be profitable if environmental costs were taken into account – including, not surprisingly, coal-fired electricity generation in the USA, but also cattle ranching in South America and wheat production in East Asia.[18] Less obviously, environmental disasters also have the potential to increase GDP in the short term. Two months after BP's Deepwater Horizon oil spill began in the Gulf of Mexico, some Wall Street analysts noted that this disaster was likely to cause a slight increase in US GDP in the coming year.[19]

The world's worst marine oil spill poured some 780,000 cubic meters of crude oil into the sea over five months in 2010, disrupting livelihoods as well as causing environmental damage. Most affected were the large tourism and fisheries industries around the Gulf of Mexico coastline and the oil industry itself, which faced a moratorium on deep water drilling. Sales of products and services suffered dramatically as a result of the disaster and thousands of employees were laid off, with the effects rippling outward through the regional and national economies, dragging down GDP. Even so, Wall Street economists estimated that the enormous expenditure on the clean-up effort, including hiring thousands of unemployed workers, would more than offset this damage, leading to an overall increase in GDP.

17. http://www.investopedia.com/ask/answers/030915/what-percentage-global-economy-comprised-oil-gas-drilling-sector.asp.
18. Trucost, Natural Capital at Risk, 2013
19. "Oil spill may end up lifting GDP slightly," Wall Street Journal, 15 June 2010.

As well as environmental disasters, GDP includes spending to deal with everyday environmental clean-up. Across the 28 member states of the European Union, total spending on environmental protection – much of it day-to-day, and some of it in the form of long-lasting investments in plant and equipment – is estimated to run at over EUR 300 billion per annum or about 2.1% of total GDP in the EU.[20]

Perhaps the greatest shortcoming of GDP to guide the management of our economy is that it fails to reflect the impact of activities on the long-term health of the planet or its "natural capital." The arguments to value natural capital are parallel to the economic arguments to value other forms of capital. GDP is a measure of flow or rate. Rather than being obsessed with the rate of production of goods and services, some economists have long argued that we should concentrate as much or more on the overall wealth of nations and how this is created, maintained and distributed. To maintain the flow of goods and services, we have to maintain all of the things that provide them, which we call capital. To grow the economy in the long term, we have to increase capital.

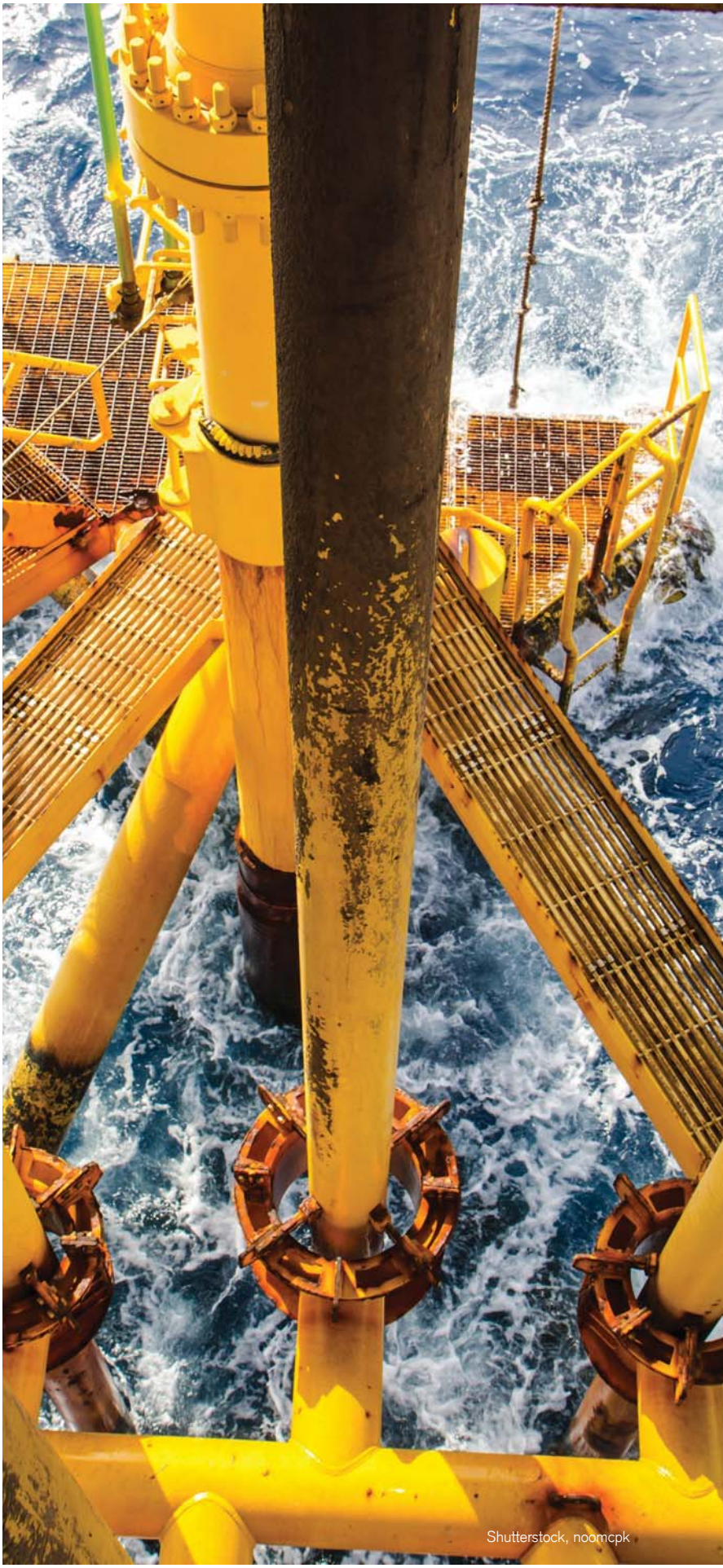
We need to think about natural capital

Capital is used, along with other factors of production such as labor, to produce the flow of goods and services that make up an economy. In traditional economics, capital is anything man-made that is used to provide goods or services, including factories, machinery and money. Other forms of "intangible capital" – human, social, institutional and intellectual capital (sometimes collectively referred to as "social capital") – are all critical to production and economic growth, but they are more difficult to assess and measure in monetary terms than "ordinary" man-made capital. Education can clearly be seen as contributing toward social capital and enabling economic growth. So can good health.

"The goods and services provided by nature and ecosystems are an essential (albeit taken for granted) part of any economy"

More recently, nature is also being recognized as an essential source of capital. The goods and services provided by nature and ecosystems are an essential (albeit taken for granted) part of any economy. Fresh water, breathable air, fertile soil, pollination, renewable energy sources, a relatively stable climate and the assimilation of pollution and waste – all flow from natural capital. Like man-made capital, natural capital can increase

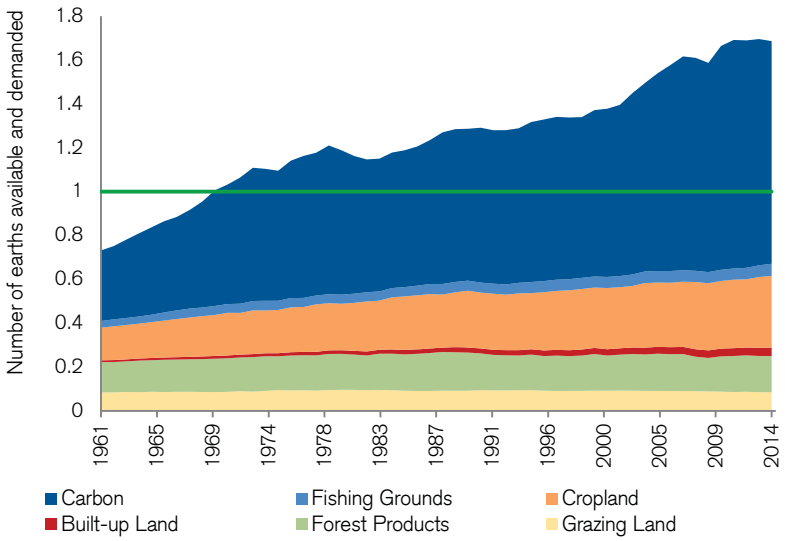
20. Eurostat, Environmental protection expenditure accounts, accessed 25 August 2017. http://ec.europa.eu/eurostat/statistics-explained/index.php/Environmental_protection_expenditure_accounts.



Shutterstock, noomcpk

Figure 3

World ecological footprint by component



Source: Global Footprint Network

and grow, thereby increasing prosperity – or it can diminish and depreciate, threatening our future prosperity and well-being and resulting in real economic damage. Seeing "natural resources," "the biosphere" or "the environment" in this way implies that it is critical, measurable, limited and modifiable upward or downward. A report by the Chartered Institute of Management Accountants made the claim: "Natural capital will become as prominent a business concern in the 21st century as the provision of adequate financial capital was in the 20th century. Natural capital underpins all other forms of capital, including financial – ultimately we rely on it for everything."[21]

Different ways are being proposed to account for natural capital, the services it provides and our impact on it. Various initiatives are underway, looking at global, national and project-level data – including the System of Environmental-Economic Accounting (SEEA)[22], the UK Office for National Statistics' National Capital Project[23] and the Royal Institute of Chartered Surveyors' Natural Capital Planning Tool.[24] The methodologies are emerging, but it will take time for accounting conventions to be generally agreed upon. But, when we look at some of the headline indicators of natural capital, we see Commander Culbertson's simple observation in stark numbers.

21. EY, International Federation of Accounts and the Natural Capital Coalition for the Chartered Institute of Management Accountants, 2014, Accounting for Natural Capital.
22. https://seea.un.org.
23. https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital.
24. http://www.rics.org/Global/Natural_Capital_Planning_070116_dwl_aj.pdf.

The Zoological Society of London (ZSL) estimates biodiversity loss by estimating overall changes in abundance using 14,152 monitored populations of 3,706 different species from every continent and ocean. ZSL's data estimates that the number of vertebrates – animals with backbones – living wild in the world fell by a staggering 58% between 1970 and 2012, as reported in the Living Planet Index.[25] This precipitous decline over four decades is the result of growth in the human population and economy – seas are over-fished, and terrestrial habitats are ploughed up, grazed on, deforested, drained, burnt and built over.

"We are consuming resources 50% faster than the planet's natural capital can regenerate them"

Ecological footprinting is another indicator of the demands we make on the natural capital of the planet.[26] It is an accounting methodology that relates our consumption of resources to the ability of the planet's productive land and seas to produce those resources, the "planet's biocapacity" measured in global hectares, e.g. the area of cropland or fisheries to produce food, or area of forest to provide timber or to absorb carbon dioxide. The footprint can in turn be converted to "number of planets" worth of biocapacity required to support consumption on a sustainable basis. This form of accounting suggests that, globally, we are consuming resources at a rate that is 50% faster than the planet's natural capital can regenerate them. Our budget is around 1.7 global hectares per person. This means, for example, that if everyone on earth had the ecological footprint of the average Swiss person with a footprint of 5.3 global hectares, then we would need three planets to support us. If we all lived like Americans, we would need five planets.[27]

So, undoubtedly, alongside all the social good that has been achieved by economic growth to date, it has degraded natural capital on a very large scale. Environmental issues are not a new problem.

25. ZSL, GFN and WWF.2016. Living Planet Report 2016 – Risk and Resilience in a New Era. WWF International, Gland, Switzerland.
26. www.footprintnetwork.org.
27. These data have led my organization, Bioregional, to create the concept of One Planet Living – where people everywhere can lead happy and healthy lives within the environmental limits of our one planet. www.bioregional.com/oneplanetliving.

Academics such as Jared Diamond have documented and popularized the result of human activity on worsening environmental pollution and degradation that has damaged human health, economies and social cohesion – sometimes to the point of crisis and civilizational collapse.[28] These problems have affected ancient city states and small islands, then the large conurbations that sprang up after the industrial revolution, and then entire regions and nations. It is only more recently that they have reached the point where they threaten entire planetary systems that underpin life on earth.

GDP growth as it stands will not solve environmental problems

It has been argued that GDP growth is an indispensable part of the solution to environmental problems and that only an increase in resources, and organizational and technological innovation brought about by GDP growth can fix them. One way of framing this argument is the "Environmental Kuznets Curve."[29] The hypothesis is that if nations' GDP per capita is plotted on the horizontal x axis of a graph and environmental damage on the vertical y axis, the result is an inverted U-shaped curve. The poorest, least-industrialized countries show very low levels of damage. In nations where industrialization has commenced and GDP has increased, environmental damage increases rapidly. However, when GDP rises above a certain level, countries begin to solve their environmental problems and reduce the damage.

The key paper making this argument looked at data from some 20 nations on urban air pollution and water quality.[30] According to the authors, "Contrary to the alarmist cries of some environmental groups, we find no evidence that economic growth does unavoidable harm to the natural habitat…air and water quality appear to benefit from economic growth once some critical level of income has been reached." The authors suggested this level was less than USD 8,000 of GDP per capita in 1985 USD.

It does indeed appear that the wealthiest, highest-income nations in the world are generally the best at protecting the environment within their own borders. We can see this if we examine the results from Yale University's Environmental Performance Index.[31] This ranks the great majority of the world's nations on how well they look after their own ecosystems and protect human health from pollution, using 24 indicators.

Switzerland occupies the number one spot in the 2018 rankings. The 20 top-rated nations for environmental protection are all among the top 40 in terms of GDP per capita, adjusted for purchasing power parity. But, on some measures, even the world's

28. Diamond, Jared, 2005. Collapse – "How societies choose to fail or survive," Viking Penguin, New York.
29. The Kuznets Curve, proposed by the Nobel Prize-winning economist Simon Kuznets in the 1950s, held that as income (or GDP) per capita rose in a nation, inequality first of all increased but after a certain point it began to decrease. As with the Environmental Kuznets Curve, that proposal is highly debatable.
30. Grossman G and Krueger A, 1995. Economic growth and the environment. The Quarterly Journal of Economics, 110:2, pp 353-377.
31. Yale University Environmental Performance Index, https://epi.envirocenter.yale.edu.

Table 1

Yale University's Environmental Performance Index

Nations ranked by position on Environmental Performance Index 2018 (out of 180 nations)	Rank order for GDP per capita, 2016, adjusted for purchasing power parity (out of 190 nations)	Estimated GDP per capita, USD 2017, ppp adjusted	Rank order for material footprint per capita (out of 172 nations)	Material footprint per capita, tons, in 2010 (latest data available)	UN Human Development Index ranking 2015 out of 188 nations (latest data available)
1. Switzerland	9	61,422	15	26.6	2
2. France	28	43,761	28	22.0	21
3. Denmark	20	48,883	18	25.3	5
4. Malta	30	41,945	40	19.5	33
5. Sweden	16	51,474	31	21.5	14
6. United Kingdom	27	44,118	42	18.9	16
7. Luxembourg	2	106,374	1	100.1	20
8. Austria	21	49,869	12	30.8	24
9. Ireland	5	75,538	11	31.2	8
10. Finland	26	44,333	6	35.8	23
11. Iceland	15	51,842	14	27.3	9
12. Spain	33	38,286	21	24.2	27
13. Germany	17	50,425	29	22.0	4
14. Norway	6	71,831	6	35.8	1
15. Belgium	24	46,553	34	20.5	22
16. Italy	34	38,140	33	20.7	26
17. New Zealand	32	38,934	32	21.2	13
18. Netherlands	14	54,777	20	24.7	7
19. Israel	37	36,340	43	18.1	19
20. Japan	29	42,832	37	20.1	17

Source: IMF, UN SDG Indicators Global Database, United Nations Development Programme

wealthiest nations are failing to look after aspects of the environment within their own borders. The UK's latest State of Nature 2016 report pools data and expertise from more than 50 nature conservation and research organizations.[32] It found a 16% drop in the abundance of 2,501 monitored terrestrial and freshwater species in the UK between 1970 and 2013.

The Yale Environmental Index provides interesting insights, but can be deeply misleading if we are not careful. We believe this way of looking at things ignores the environmental damage wealthy countries do outside of their borders – sometimes described as spillover effects. Over the last 50 years, there has been a great migration to, and expansion of, polluting heavy industry in low- and middle-income nations, where environmental standards are generally lower. Developing nations have supplied more and more of the raw materials and natural resources that economies and economic growth depend on everywhere. The natural capital of these developing countries has been heavily degraded as a consequence.

Middle-income emerging nations that have maintained high GDP growth rates generally gain low scores in this Environmental Performance Index, with China ranked 120th and India 177th. But the world's poorest, lowest GDP per capita nations, largely in sub-Saharan Africa, are found predominantly near the bottom end of the rankings for environmental performance.

"Rich countries are devoting resources to tackling environmental problems within their own borders, but contributing to environmental damage elsewhere"

To understand what is happening, the system has to be looked at as a whole: we need to consider the global environmental "footprints" of nations. These footprints try to portray how the final consumption of goods and services in one nation affects the environment across the globe. As mining, manufacturing, agriculture, energy production and other activities required to support rising consumption expand, so too does deforestation and over-fishing, water abstraction, waste production, pollution and greenhouse gas emissions. It is difficult to aggregate these dispersed and complex impacts – the ecological footprinting described earlier is one attempt, but footprint estimates for greenhouse gas emissions, land use, water use and basic or raw materials represent the most detailed efforts so far.

The material footprint is an estimate of how many tons of raw materials of all kinds from across the globe are required to support a nation's consumption of goods and services for one year.[33] It includes renewable materials such as crops and timber, and non-renewables like minerals. The material footprint embraces raw materials grown or extracted within that country plus all of those required for what it imports, but excludes those domestically sourced raw materials that go into its exports. Since growing, extracting and processing raw materials have heavy and wide-ranging environmental impacts, the material footprint is a strong surrogate for global environmental impact.

The average per capita material footprint across the entire planet is 10.1 tons[34], meaning that the average human being requires over ten tons of raw materials to be grown or extracted every year. But there is a wide material footprint range between nations. Nearly all developed, high-income countries have per capita material footprints of more than 30 tons, while a few exceed 100 tons. The least developed countries have per capita material footprints of less than four tons. Looking at the 20 nations scoring highest in the Environmental Performance Index, all of them have high material footprints well above the global per capita average. The same picture emerges when we look at the "land footprint" of nations – the amount of land they require, per capita, across the globe to support their own population's consumption.[35]

The big picture is one of rich countries devoting resources to tackling environmental problems within their own borders with some success, but contributing to environmental damage elsewhere as their economic growth continues. The same narrative seems likely to play out as emerging giants like China tackle the huge backlog of environmental degradation within their borders, attempting to attain both the living standards and the environmental standards of the developed world.

Carbon dioxide emissions are decoupling from GDP growth – but this does not mean environmental damage is slowing

It is not all bad news. For example, there is evidence that GDP growth is "decoupling" from burning fossil fuels. The move from coal to gas and the massive expansion in renewable energy generation are the main contributors, with the International Energy Association reporting that global investment in renewables is now exceeding the amount invested in fossil fuels.[36] Between 1990 and 2016, global GDP more than doubled, while annual carbon dioxide emissions from burning fossil fuels and cement manufacturing increased by 62% over that same period. In 1990, 0.59 kg of carbon dioxide was emitted from fossil fuel burning and cement manufacture for each dollar of global GDP produced and by 2016 that figure had

32. Hayhow D et al, 2016. State of Nature 2016. The State of Nature partnership.

33. Wiedmann T et al, 2015, "The environmental footprint of nations," PNAS, 112:20, pp 6271-6276.
34. UN Statistics Division, Sustainable Development Goals Database, https://unstats.un.org/sdgs/indicators/database.
35. Weinzettal J et al, 2013, "Affluence drives the global displacement of land use," Global Environmental Change, 23:2, pp 433–438.
36. https://www.iea.org/publications/wei2017.

fallen to 0.47 kg (using constant 2010 US dollars). So, globally, economic activity is decarbonizing – there is less CO2 emitted per unit of goods and services produced. But the latest authoritative estimate is that carbon dioxide emissions are rising again after three years of near stasis, with a 2% growth estimate for 2017.[37]

In any case, stabilizing global CO2 emissions at their current level will not prevent dangerous climate change – rapid reductions are required in order to do this. While decoupling is obviously a very good trend, we see from footprint analysis and the data on planetary boundaries that growing GDP is still mostly associated with increasing environmental damage.

Other headline indicators of progress exist

It has, of course, been pointed out numerous times that GDP is not an indicator of welfare or more general concepts of prosperity. Therefore, other indicators have been proposed, including the United Nations Human Development Index, Gross National Happiness, Genuine Progress Indicator and, most recently, the Sustainable Development Goal Index. All provide interesting insights.

"What is most important to us – happiness or consuming more products and services?"

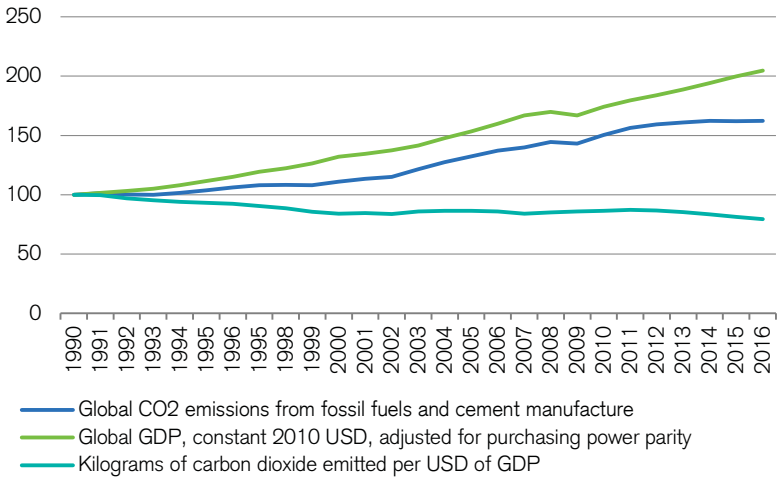
The United Nations Human Development Index (HDI) scores 188 nations based on the average life expectancy of their citizens at birth, the expected and average number of years of schooling and Gross National Income (GNI) per capita in US dollars, adjusted for purchasing power parity.[38] With an overall score of 0.949, Norway heads the latest version of the rankings, with average life expectancy of 82 years, an average of 12.7 years in school and GNI per capital of USD 67,614. Switzerland is in second place with a score of 0.939. The Central African Republic lies at the very bottom of the index with a life expectancy of 52 years, 4.2 school years and a per capita GNI of USD 587 and an HDI score of 0.352. Of the top 20 environmental performance nations, 18 are in the top 30 for the Human Development Index. It seems that high-income nations that prioritize environmental protection are strong in terms of building social capital; and those countries which perform the best in protecting the environment within their own borders also score very highly on the HDI.

37. Le Quéré C et al, Global Carbon Budget 2017, Carbon budget and trends 2017. [www.globalcarbonproject.org/carbonbudget].
38. UN Development Programme, 2016 Human Development Report. Table 1. Available at hdr.undp.org/en/composite/HDI.

Gross National Happiness (GNH) has received a lot of publicity in the past few years. The term was first used in 1979 when the then king of Bhutan said "We do not believe in Gross National Product. Gross National Happiness is more important." GNH covers psychological well-being, health, time use, education, cultural diversity and resilience, good governance, community vitality, ecological diversity and resilience, and living standards. GNH surveys are enabling the Bhutanese government to track progress. Whether GNH can be widely applicable is still up for debate, but it nonetheless asks us a very significant question that may go to the very root of how we might live sustainably on this planet – what is most important to us as individuals and societies – happiness or consuming more products and services?

Figure 4

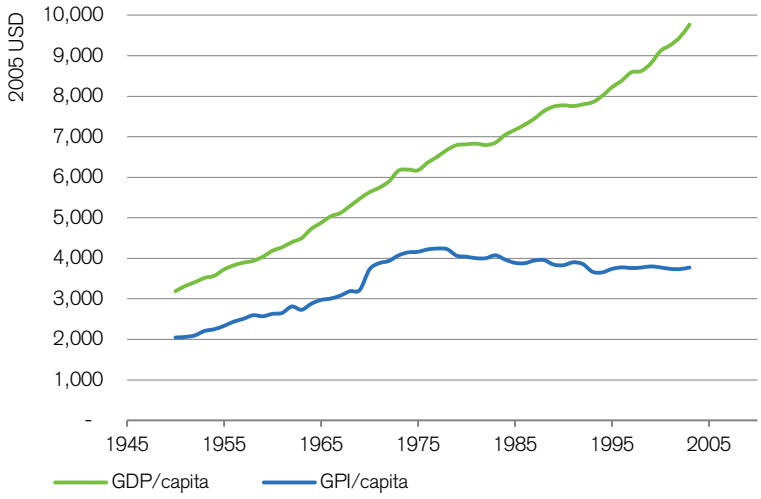
Global CO2 emission, GDP and carbon intensity
(1990 = 100)



Source: World Bank, Carbon Dioxide Information Analysis Centre, BP Statistical Review of World Energy 2017

Figure 5

Real GDP and GPI per capita, 1950–2004 (in 2005 USD)



Source: World Bank, Kubiszewski

One very interesting indicator is the Genuine Progress Indicator (GPI), which adjusts GDP to account for a range of environmental and social factors such as the costs of pollution, deterioration in natural resources, wealth inequality and the benefits of activities such as parenting. The GPI suggests that, where GDP per capita has grown fairly steadily over the period, GPI levelled off in the 1970s and is even decreasing (as shown in Figure 5).[39] GPI demonstrates that, as GDP has grown, although some people have been lifted out of absolute poverty (which is not to be underestimated), overall living conditions may not have improved, or may have even declined.

The Sustainable Development Goal Index (SDGI) assesses how countries are performing with respect to achieving the Sustainable Development Goals (SDGs).[40] The SDGs are a set of 17 global goals with 169 targets developed by a process led by the United Nations and adopted by its 193 member states in 2015. The goals are universal, covering all countries rich and poor, and include ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests.

The SDGI places Sweden, Denmark and Finland as the best-performing countries against the targets contained in the SDGs, with Switzerland in eighth place and the Democratic Republic of the Congo, Chad and the Central African Republic at the bottom. The developers of the SDGI note, however, that countries with high GDP per capita create a lot of "spillover effects" that do not occur within the countries' boundaries and include effects from over-fishing on the high seas, transboundary pollution and impacts embodied in trade, many of which affect poorer countries – so a high SDGI score does not mean that the country is sustainable. In fact, when HDI and SDGI rankings are mapped against ecological footprints, we see that no country fits squarely in the "Global Sustainable Development Quadrant" where, at least based on these measures, countries can be reasonably considered as sustainable.[41] Figure 7 shows the position of the top and bottom countries on the SDGI in terms of their HDI scores and ecological footprints. In this analysis, the countries that perform well overall include Cuba (SDGI ranking: 29, HDI: 0.77 and EF: 1.9 gha/1.1 earths), Costa Rica (SDGI ranking: 53, HDI: 0.77, EF: 2.5 gha /1.5 earths) and Sri Lanka (SDGI ranking: 81, HDI: 0.76, EF 1.5 gha/0.9 earths).

Why does GDP remain pre-eminent?

GDP's power, however, has not been significantly challenged to date by any of these other, broader indicators of progress. There may be a couple of interesting reasons why GDP continues to be the leading indicator for economic progress.

39. Kubiszewski I et al, 2013, "Beyond GDP, Measuring and achieving global genuine progress," Ecological Economics 93, pp 57–68.
40. Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D. and Teksoz, K. (2017): SDG Index and Dashboards Report 2017. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN).
41. http://www.footprintnetwork.org/2016/07/20/measure-sustainable-development-two-new-indeces-two-different-views/;© 2017 Global Footprint Network. National Footprint Accounts, 2017 Edition.

Figure 6

United Nations Sustainable Development Goals

Source: United Nations

First, economic growth (GDP growth) is required to repay debt. This requirement for debt repayment flows through our society, driving financial efficiency to the extent that it may override many other considerations. The consequence is that, among other things, it may risk fueling consumerism at a level that causes excessive environmental damage (and also contribute to wealth concentration and inequality). Economics professor and former leading currency trader, Bernard Lietaer, lays this concept out well in his book, "Rethinking Money," co-written with Jacqui Dunne.

The authors point out various ways to reduce pressure on GDP growth.[42] Governments could, for instance, increase money supply through spending (money which could, for example, be spent on green infrastructure such as public transport systems, extra renewable energy generation or planting new productive forests, all of which would preserve or build natural capital). Or money could be created through complementary currencies (including digital currencies), based on different values such as promoting the local economy or building natural capital. Without going into the advantages and disadvantages of other ways to create money, they argue that the way we currently create money contributes to the pre-eminence of GDP.[43]

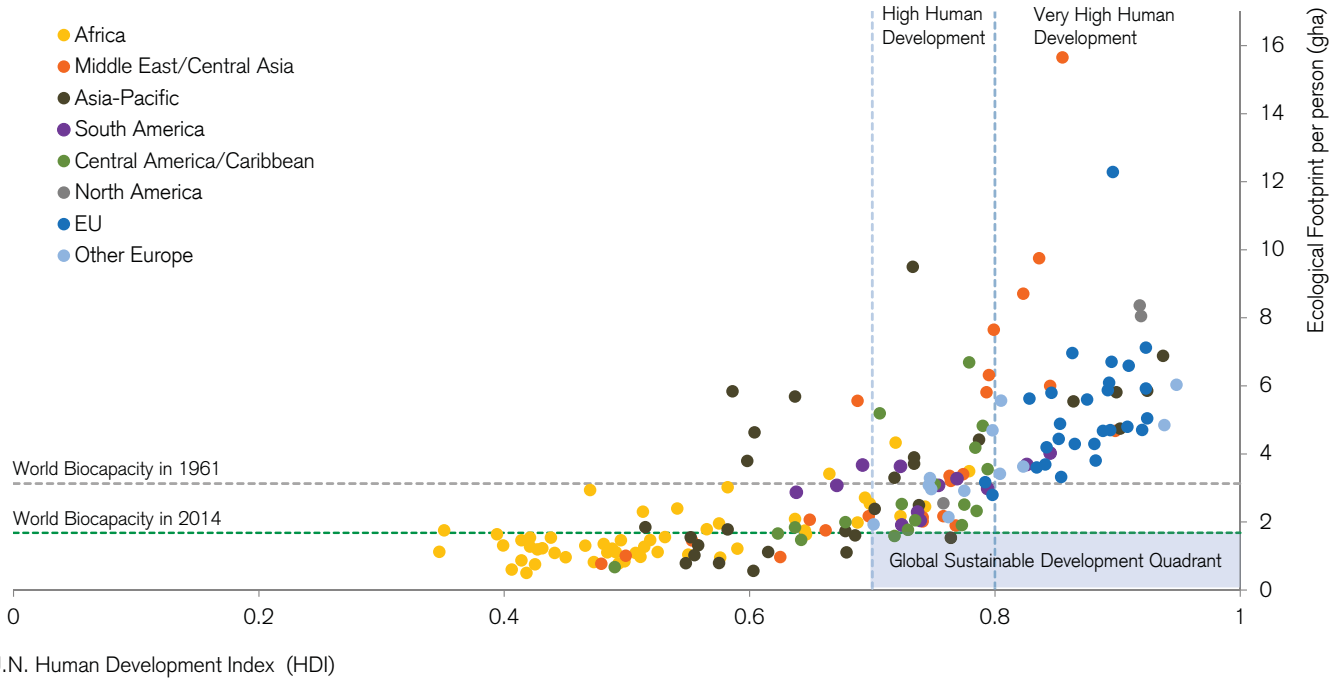
42. Lietaer and Dunne, 2013, "Reinventing Money," Berrett-Koehler Publishers.
43. Indeed, finance and economics have been almost interchangeable as words, though they should mean very different things.

A second reason for GDP's pre-eminence, and a great practical strength of GDP is that it is possible, conceptually at least, to link every transaction in the economy to GDP – or more importantly in the minds of the public, to relate the money in their wallets and their spending power to GDP. None of the other indicators of progress yet have the power to link the rewards in terms of what we earn or spend with a global indicator of progress. We believe there is a simple assumption in many people's minds: "I will be rewarded if GDP grows as I will have more in my wallet." This has a deep significance as money and the transactions it supports stimulate reward circuits in the brain[44] so that consumerism becomes "hardwired" in our brains. Indeed, this complex interplay between the shape of our economy and the pathways in our brains has given rise to the whole academic field of neuro-economics. Unless other macroeconomic indicators can replicate or replace this property of money and GDP, where individual transactions are rewarded and traceable back to one simple overall number, then it may be extremely difficult to replace GDP, even with all its drawbacks.

44. G. Sescousse, J. Redoute, J.C. Dreher, "The Architecture of Reward Value Coding in the Human Orbitofrontal Cortex," Journal of Neuroscience, 2010; 30.

Figure 7

Ecological footprint per person and HDI of countries by world regions (2014)



Source: Ecological Footprint per person: National Footprint Accounts 2018 Edition, Global Footprint Network. Human Development Index: Human Development Report, UNDP 2016

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What options are there to correct our trajectory?

Sustainable development is often proposed as the solution to the challenges we face and is often described as having three pillars – social, environmental and economic. If sustainable development is the solution, then we can think of strengthening each of the three pillars of sustainability and hence creating a prosperous future by building social, natural and financial capital. At the moment, although we are building financial capital, the data shows us that we are also destroying natural capital and may be damaging social capital.

If we look at natural capital, we believe we possess a lot of the knowledge, processes and technologies to have a good go at addressing the challenges of climate change and other planetary boundaries and thereby to build natural capital. Potential solutions range from organic and regenerative farming (which can rebuild soils) and renewable energy technologies[45] to circular-economy concepts such as eliminating waste and pollution, recycling products and materials, and regenerating natural systems. The real issue now is whether the solutions can be deployed and damaging activities can be curbed fast enough to avert the widespread collapse of natural systems.[46] Currently, many solutions are not "economically viable," by which we really mean "financially viable," while many products and services that damage the environment are. Assuming we stick with a market-based future, we will need to shape the market so that building natural and social capital is economically viable and financially profitable. In our view, we can do this through regulation or by "internalizing" environmental costs.

"Although we are building financial capital, the data shows us that we are also destroying natural capital and may be damaging social capital"

We are all familiar with environmental regulation – whether this be local (as with local air quality standards) or regional (e.g. European Union standards on energy efficiency). However, as many of the planetary boundaries depend on global issues, we believe we would need global regulation. Although this may be hard to envisage, there is one outstanding precedent. As a global society, we did rise to the threat of the widening hole in the ozone layer, one of the nine planetary boundaries. Stratospheric ozone protects much life on earth, including humans, from overexposure to damaging ultra-violet rays from the sun. In the 1980s, a hole was observed in the ozone layer and recognized as a serious threat.

45. Ed.Paul Hawken, 2017, "Drawdown," Penguin Books.
46. https://www.ellenmacarthurfoundation.org/circular-economy.

Damage to the ozone layer had been linked to emissions of certain refrigerant and aerosol gases, most notably chloroflourocarbons, or CFCs. In 1987, international agreement was reached and the Montreal Protocol was put in place to regulate ozone-depleting substances. The ozone layer has started to repair itself,[47] which is a major example of how science, political will at the global level, and the private sector can join together to solve an issue of planetary health.

"The question is whether the market can be harnessed to build natural and social capital and whether GDP can in fact help us in this endeavor"

As well as – or in addition to – regulation, we believe the market can be shaped by internalizing environmental costs, or at least incentivizing the deployment of certain products or services. This could be achieved through taxes or trading schemes (e.g. for carbon) and grants or incentives (e.g. for renewable energy or wildlife-friendly farming). While these schemes and incentives have had varying success, much has been learned from them. Some, such as all the initiatives that have collectively resulted in the growth of renewable energy, have been very successful.

Whatever strategies we choose to use – and there will be many – we believe the urgency of the situation with climate change and other planetary boundaries such as the nitrogen cycle, phosphorus cycles and genetic diversity will require a transformation in our economy at a rate, scale and comprehensiveness that is hard to comprehend. Given that the market is such a powerful force, the question is whether it can be harnessed to build natural and social capital and whether GDP can in fact help us in this endeavor.

Can we adjust GDP to account for natural capital and planetary boundaries?

As we know, GDP is a very powerful indicator and difficult to dislodge. Can we conceive of a way to adapt GDP so that its growth reflects the building of the biosphere and natural capital, and use this to help steer the economy toward the necessary outcomes?

As we have seen, the Genuine Progress Indicator is one example where GDP has been modified to take a number of environmental and social impacts into account. This is useful, but we believe GPI itself lacks the deep connection that GDP makes by linking individual transactions and rewards to people's understanding of how the economy works, or at least how they think it works. Technology may be able to help – an increasing proportion of transactions are now tracked electronically, which enables us to start envisaging systems where each transaction in the economy carries information about its impact on natural and social capital. And we can imagine that this information could incentivize those products and services that add to natural and social capital, and discourage those that do not. It might be useful to think of this in terms of "quality."

The quality of each dollar spent in the economy is not the same. In this framework, a dollar spent on renewable energy or organic fair trade food would be a high-quality dollar contributing to building natural and social capital. A dollar spent on fossil fuels might be categorized as destroying natural capital and a dollar spent on clothes made with child labor would reduce social capital. We can imagine each dollar transaction being "quality adjusted" based on its impact on natural and social capital. Summing up these transactions, "quality-adjusted dollars" could provide us with a "quality-adjusted GDP," one that is adjusted for natural and social capital. GDP is already adjusted on the basis of other forms of quality, e.g. on the quality of goods and services through hedonic pricing – so why not adjust for impact on natural and social capital? If we could do this, we think it is just possible that we could be "transacting our way" to a better future.

GDP falls well short of our needs today

We began writing this chapter when Texas was coming to terms with the flooding and devastation brought by hurricanes Harvey and Irma to mainland USA and a number of Caribbean islands. We could imagine an astronaut looking down on Spaceship Earth and paraphrasing another popular quote: "Houston, you have a problem."

"True prosperity is when we are building natural and social capital at the same time as financial capital"

If Christiana Figueres and her colleagues are right, we have until 2020 to stabilize carbon emissions and then start bringing them down rapidly. In our view, it is hard to exaggerate the seriousness of our predicament. We have to create ways of living that are not just consistent with the need to maintain a stable climate, but also with the need to address all the other eight planetary boundaries as well. Our economy needs to nourish the biosphere and promote its health. The challenge is not trivial. It will require deep systemic change and that will include how we measure success. GDP falls well short of our needs today. True prosperity is when we are building natural and social capital at the same time as financial capital. GDP needs to change to reflect this fact or we need to give prominence to another indicator. ■

47. http://news.nationalgeographic.com/2016/06/antarctic-ozone-hole-healing-fingerprints.

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Switzerland: Outperforming GDP data

Switzerland is considered to be one of the wealthiest nations in the world and frequently ranks close to the top in terms of living standards. Yet, measured in terms of Gross Domestic Product, its long-term growth rate lags behind that of other countries. According to the Organisation for Economic Co-operation and Development, the Swiss domestic economy has on average had the lowest price-adjusted GDP growth of all the industrial countries over the past 50 years.

Claude Maurer, Head Swiss Macro Analysis & Strategy at Credit Suisse

Although we do not see a viable alternative, GDP shows clear inefficiencies as a proxy of economic performance particularly in Switzerland, notably due to the global nature of some of the key Swiss business sectors.

- World's leading sports associations including the Fédération Internationale de Football Association (FIFA), the Union of European Football Associations (UEFA) and the International Olympic Committee (IOC) are headquartered in Switzerland and the license income for major sports events is an important part of Swiss GDP. In fact, according to SECO, if a world sports gala does not take place one year, the immediate impact on Swiss GDP amounts to up to 0.3%. We believe that the figures derived from these activities and flowing into Swiss GDP have an extremely limited impact on the Swiss real economy.
- While having limited access to commodities, Switzerland does substantial business in commodities trading, amounting to around 4% of GDP. This significant contribution also stands in contrast to the small number of people employed in the segment (estimated at 36,000) and the fact that it is not included in the conventional statistics. The price-sensitive commodities sector is thus highly relevant for Swiss GDP, although the product never crosses Swiss borders.

The convergence phenomenon

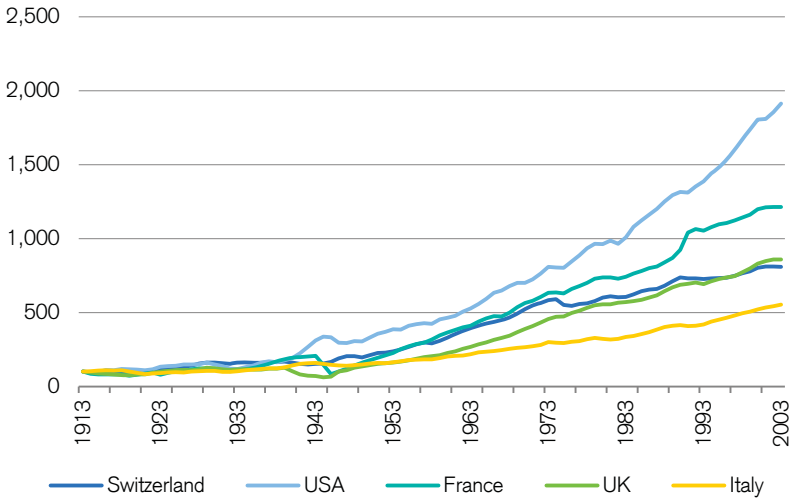
It can be argued that a high level of wealth is naturally connected to low economic growth, as the "convergence phenomenon" suggests. Accordingly, countries with lower living standards grow faster to catch up with wealthier societies. Often, economic growth can be sped up by replicating established production processes of developed economies, where growth tends to be restrained by high levels of human and physical capital. As a result, further capital investment in developed economies tends to have a comparably small effect on growth.

However, even when considering longer time series for Switzerland, we find that between 1871 and 2003, economic growth was lower than in neighboring countries, as indicated in Figure 1.

Figure 1

Moderate Swiss GDP growth over the long term

Real per capita GDP, index: 1913 = 100



Source: Federal Reserve System, Datastream, Credit Suisse

Throughout the 19th century, Switzerland ranked below its European neighbors in terms of wealth, so according to the "convergence phenomenon", its GDP growth should have been higher while it was catching up. Interestingly, even in periods of fast growth, Switzerland did not rank above European average (see Figure 2).

The paradox of GDP growth and high living standards

The paradox of posting relatively low GDP growth while enjoying high living standards at the same time has repeatedly sparked discussions in Switzerland about the usefulness of GDP data.[1] In addition to weaknesses of GDP metrics as a measure of performance and well-being discussed in other chapters of this report, we find that GDP performs particularly poorly in capturing activities that play an important role in the Swiss economy, notably financial services, research and development.

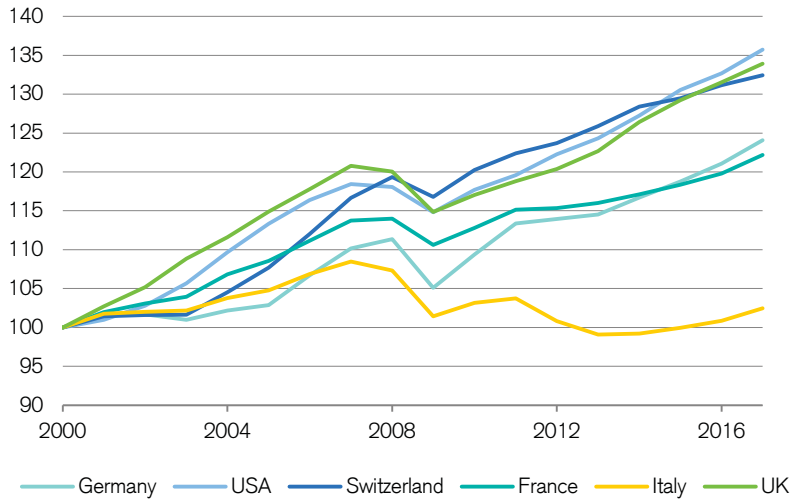
An important aspect from the Swiss perspective is that improvements in the so-called "terms of trade" are not considered in GDP calculations.[2] The terms of trade refer to the ratio of export and import prices. Accordingly, when export prices rise – or import prices fall – more can be purchased abroad for the same input of labor and capital, i.e. countries can afford to import more when import prices drop. But since imports are deducted at constant prices in the System of National Accounts (SNA), from which GDP is derived, the resulting statistics are understated.

1. "die Volkswirtschaft" magazine https://dievolkswirtschaft.ch/de/schwerpunkte/sinnhaftigkeit-von-bip-zahlen

Figure 2

Robust GDP growth in Switzerland in recent years

Real GDP, index: 2000 = 100

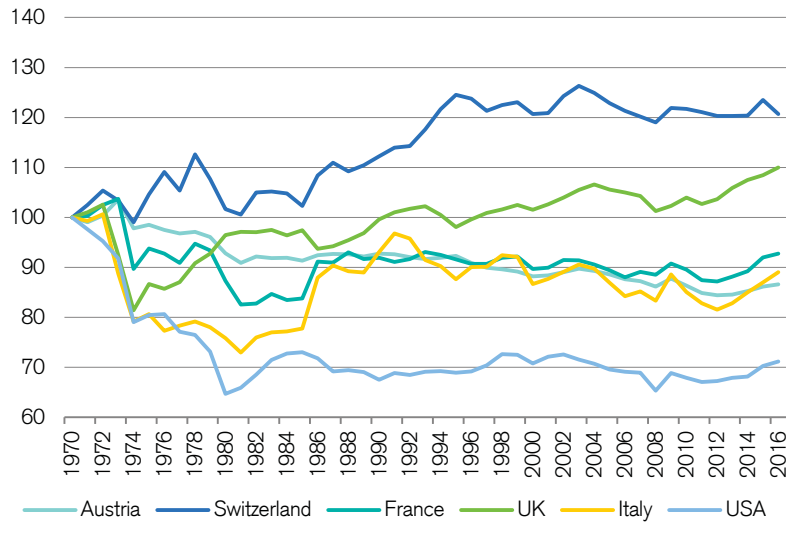


Source: OECD, Swiss Federal Statistical Office, Credit Suisse

Figure 3

Switzerland's terms of trade improved

Terms of Trade, index: 1970 = 100



Source: OECD, Credit Suisse

"GDP performs particularly poorly in capturing activities that play an important role in the Swiss economy, notably financial services, research and development"

To illustrate this situation, the former Swiss National Bank Chief Economist Ulrich Kohli uses the analogy of a farmer growing wheat, hiring workers and buying fertilizer.[3] If the price of imported fertilizer falls while the price of grain stays constant, then the farmer's net income increases even if he does not produce and sell more wheat. Obviously the farmer will try and use more fertilizer at the lower price to increase production. But the increased use of fertilizer will probably only slightly increase the amount of wheat produced as the marginal productivity of the fertilizer decreases. It would be absurd to simply subtract the quantity of fertilizer used from the quantity of wheat produced to conclude that the real value added by the farmer has fallen. But that is exactly how it is done with the calculation of real GDP in the SNA.

For Switzerland, the "terms of trade" effect is particularly impactful for two reasons. First, exports correspond to more than half of the Swiss GDP. Second, Switzerland's terms of trade have improved significantly over the past few decades (see Figure 3), closely linked to the appreciation of the Swiss franc. Over the last century, the Swiss franc has gained value significantly when compared to the 21 most important currencies both in terms of real prices and after adjusting for purchasing power.[4]

2. See Eichenberger, Neue Zürcher Zeitung 27/9/2014 "Wie wir uns arm rechnen," and ,Kohli, U., "Terms-of-trade changes and real GDP," in Quarterly Bulletin 2/2002 – Swiss National Bank, pp. 54–63.).
3. Kohli 2002 Ibid.
4. See CSRI Report "Switzerland: A Financial Market History," Credit Suisse, June 2017.

GDP adjusted for terms of trade

An alternative measurement system to account for the terms of trade effect on GDP is the "command-basis" GDP, which has been discussed in the past in Switzerland.[5; 6] Using OECD data, our calculations for command-basis GDP point to the following (see Figure 4): Cumulated over the period from 1970 to 2017, Swiss command GDP has risen approximately 10% more than real GDP - compared to other industrial countries such as France, Italy, Austria and the USA, where command GDP was even slightly less than real GDP growth over the same period. We believe this result more accurately captures the development of the Swiss economy.

"Cumulated over the period from 1970 to 2017, Swiss command GDP has risen approximately 10% more than real GDP. We believe this result more accurately captures the development of the Swiss economy"

Nevertheless, command-basis GDP is not yet an internationally applicable metric. It is currently calculated and reported by only a few countries, so that international comparison is not possible. Also, three different datasets are available for export prices alone in Switzerland: The average export price index from the Swiss Customs Administration (used by the KOF to calculate the terms of trade), the export price index from the Swiss Federal Statistics Office and the export deflators from the National Accounts compiled by the State Secretariat for Economic Affairs (SECO). We use the deflators in order to take international trade with services into account. The terms of trade differ considerably depending on the basis of calculation that each institution uses, as shown in Figure 5.

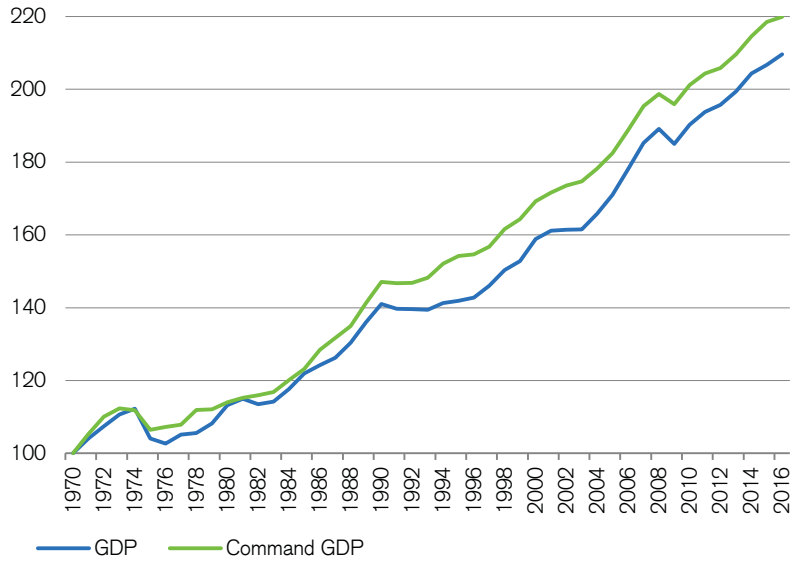
Moreover, export price statistics in Switzerland are strongly influenced by the chemical and pharmaceutical industries, which represent 35% of the weight of the export price index and 23% of the import price index. The rapidly changing range of products in these industries presents a major challenge when comparing prices. Furthermore, large companies account for an exceptionally high share of trading volumes, especially in the pharmaceutical segment, and an

5. Siegenthaler, M. (2014): "Has Switzerland Really Been Marked by Low Productivity Growth? Hours Worked and Labour Productivity in Switzerland in a Long-Run Perspective", Review of income and wealth 2014.
6. Neue Zürcher Zeitung 27/9/2014 "Wie wir uns arm rechnen," op cit.

Figure 4

Increase in command GDP stronger than for conventional GDP

Real GDP and command GDP, index: 1970 = 100

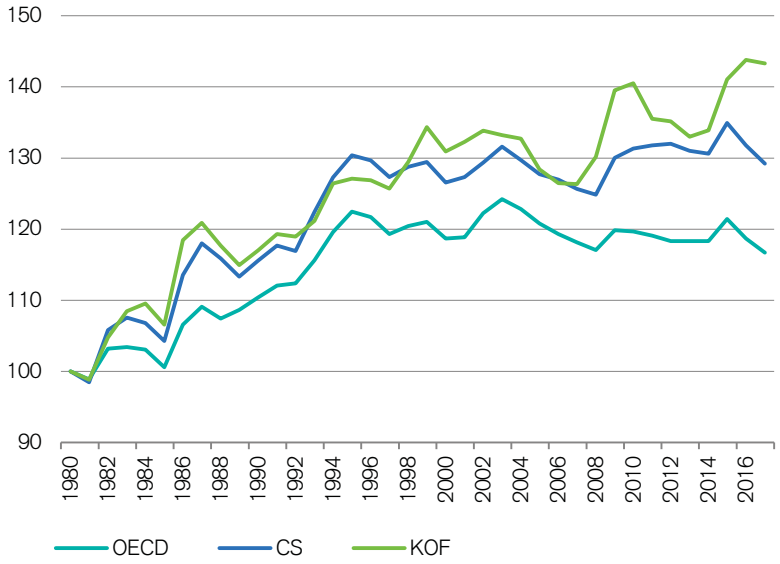


Source: Datastream, Credit Suisse

Figure 5

Terms of trade differ according to how they are calculated

Terms of Trade, index: 1980 = 100



Source: KOF, OECD, Datastream, SECO, Credit Suisse

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estimated 75% of sales are based on internal pricing. These prices can have a market or cost component, but can also be influenced by other factors such as corporate policy or fiscal considerations. The same applies to commodity prices, which have a disproportionately high weighting. These challenges make it difficult to derive exact data nationally and even more so for the use of international comparison.

"Export price statistics in Switzerland are strongly influenced by the chemical and pharmaceutical industries"

Another aspect to consider is the impact of appreciation of the Swiss franc beyond the terms of trade. Such appreciation results in an immediate improvement in the terms of trade, while simultaneously the competitiveness of domestic companies is likely to be weakened and thus result in lower economic growth. From a command-based GDP perspective, the economic development immediately after the EUR/CHF exchange-rate floor was abandoned in January 2015 tends to be too positively skewed. Although the subsequent steep appreciation of the Swiss franc led to an immediate increase in purchasing power, this increase was largely theoretical. In practice, the price transfer to Swiss businesses and households was limited while, at the same time, economic slowdown and the rising unemployment due to currency appreciation were real. ■

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The CSRI Academy is a global virtual academy that brings together bright-minded students and recent graduates to jointly develop fresh perspectives around key social and economic trends that drive today's societies. It was launched in 2016 in partnership with Project Firefly to encourage the young generation to think critically about developments that shape the world around us. The academy focuses on talented individuals irrespective of whether they come from elite universities or have significant work experience. It identifies and develops talented students and recent graduates who otherwise might not have had the chance to work with research experts and thought leaders. Twelve of our Academy members, namely Stefani Kostadinova, Sergey Valeryevich Litvinenko, Julian Theseira, Teemu Alexander Puutio, Michael Carney Pomeroy, Kanishk Patel, Radoslav Dragov, Laurent Michiels, Kamil Mikulski, Mariela Naydenova, Gavrilo Randjelovic and Bae Dae Yeon, have jointly authored a chapter in this CSRI publication.

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