4 THE CAPITALS

Imagine you visit Russia. Someone asks you what it is like, and in particular about its economy. You might google its GDP. It is about 80 per cent that of Italy.[1] Would this be a good answer to the question? What about its vast oil and gas reserves, its northern forests, the great Lake Baikal, the Arctic resources? What about the cities, the roads and railways? And then there are its military and its reliance on the commanding heights of the state and the oligarchs who loot them – Gazprom, Rusal, Rosneft and so on.

A better answer would highlight the fundamental difference between Russia and Italy. Russia is overwhelmingly dependent on its natural capital. It has been exploiting and using up its natural capital since its early origins – first timber and animal furs, then coal and now oil and gas. Oil and gas now make up around 40 per cent of government revenues and around 20 per cent of its GDP. All natural resources make up about 60 per cent of its GDP, and whilst its GDP is quite small, Russia is the world's fourth largest carbon polluter.

This answer reveals something very different from Russia's GDP. It is focused on the core assets of the economy, and in particular its natural capital endowments, and their exploitation. These are what matters,

[1] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=RU. See for a variety of economic data on Russia: https://datacommons.org/place/country/RUS?utm_medium=explore&mprop=amount&popt=EconomicActivity&cpv=activitySource per cent2CGross DomesticProduction&hl=en.

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though assets and the systems they are embedded in hardly feature in economics textbooks. These are all critical for pollution and its control.

There are four core capital asset classes that matter for the sustainable economy: natural capital, physical capital, human capital and social capital. These differ from the rest of the capitals in the economy because they mostly come as systems, and are necessary for the economy to function, because all economic activity goes through them. These systems, in which the capitals are embedded, are mostly highly capital-intensive with low to zero direct usage costs (near-zero marginal costs), and the infrastructures they comprise are best regarded as assets-in-perpetuity, and all span the obligations to the next generation. The contrast with the conventional economists' approach is stark: economics is all about the margin and marginal cost, and about flows of outputs, discounted back to the present. The focus of the sustainable economy could not be more different. This is a world far away from short-term use and throw-away consumerism.

The key feature of a system is that everything depends upon everything else. Systems do not come in marginal bits. Each bit that is added has an impact on the system *as a whole*. Add a new motorway to the road network and it will change the traffic flows throughout the system and change the road system's resilience to closures. Add a nature-based flood alleviation scheme upstream in a river catchment, and it will affect water quality and biodiversity all the way down the catchment to its estuary and beyond. Connect up a rural area to broadband and mobile phone networks and every household and business will be able to fully engage in the digital economy, and the structure of that rural economy will be open to new businesses and enterprises relying on a digital marketplace. Take away a keystone species, and the whole ecosystem shudders.

Not only does everything in each system depend upon everything else in that system, but each system depends upon the other systems too. The energy network depends upon the communications system, and the transport and water systems depend upon energy, and so on. All of them depend upon natural capital.

Natural Capital – the Primary Asset

Natural capital is the primary building block of the sustainable economy. It is what nature gives us for free. It is our inheritance, which has evolved and developed over the last 4 billion years. Everything we are

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and have is ultimately derived from this natural capital inheritance. Temporarily in our specific geological time, it has given us our specific lives and the lives of all the other creatures on this planet: the fungi, the plants, the mammals and the invertebrates. In a state of constant flux in geological time, climate change is normal. Extinction is normal. Both have been necessary to produce us. Over aeons of geological time, or perhaps much sooner, we too will go from ashes to ashes. But just not right now. We need the stability to let the world roughly remain as it is, not because it is in any sense 'optimal', but because it is the one we have evolved in and are adapted to.

To recap, natural capital comes in two types: renewable and non-renewable. Renewable natural capital renews itself. It is alive and it reproduces and keeps on giving until evolution catches up with it. Most of our food comes from life that has this characteristic, whether we think of the renewable natural capital as species, genes or complete ecosystems. Once we drive it below the critical thresholds, it stops being renewable, and goes towards extinction, thereby extinguishing its benefits forever. That is at the heart of our current environmental crises. It is first and foremost about fixing renewable natural capital.

There are lots of conservation projects to save individual species that are still hanging on from extinction, usually focused on big mammals, birds and reptiles with human-friendly faces and images. It helps too if tourists like them. Saving the tigers, the Galapagos tortoises and the Andes condors comes to mind. At often very great expense, some of these projects are successful, at least temporarily. Attempts are also made to protect key habitats, often very late in the day. Stopping fishing the once superabundant cod on the Canadian Grand Banks preserves a remnant population that might, at some distant date, make it back to abundance.[2] Some 'rewilders' believe that, humans having modified the entire planet, nature will bring lots of species back from the brink if only it is left to its own non-human devices, creating an apartheid between places where we live and places we are excluded from. This is largely a delusion – indeed, in almost all rewilding projects, active conservation is being practised rather than nature being left alone. Reintroducing wolves, beavers, sea eagles, tigers and cheetahs to old habitats is about as intensively interventionist as it gets.

[2] Even if it is too late for the Great Auk the fishers plundered, the last pair to be shot in Iceland in 1844.

These sorts of specific interventions have their place, but the really big challenges for the sustainable economy are to maintain whole ecosystems, like the Amazon, to protect the oceans as a whole and to keep the balance of greenhouse gases in the atmosphere. These big systems are what really matter in the scheme of renewable natural capital and hence the future of life on earth. They are the assets which we have a duty to bequeath to the next generation in good shape. The biodiversity crisis is not about individual species, but rather about whole ecosystems on a global scale within which the biodiversity of life functions and reproduces itself, and the climate crisis is not about just the emissions and sequestrations of one of the greenhouse gases in a specific location, but the concentration of all of them in the global atmosphere.

Life also depends on the earth's mineral-rich crust, which contains our non-renewable natural capital, and all the minerals that we rely upon. These, together with the impacts of what we do, determine the atmosphere, the landforms and the oceans. Our natural capital includes the legacy solar (and therefore ultimately legacy nuclear from the sun's nuclear fusion) energy packed into the fossil fuels that still make up that 80 per cent of our energy, and our petrochemicals and plastics. It includes the iron ores out of which we make steel, and all the chemical elements which we combine in ever more ingenious ways, and all the limestones and chalks to make cement. It holds the cobalt, lithium, nickel and copper essential to the development of electric car batteries and wind turbines. There is no decarbonisation without digging up lots and lots of these minerals. Next time you see claims about 'clean energy' and 'zero-emissions cars', ask where the minerals come from, ask how they are mined and then ask how they are refined to make the batteries and the turbines.

This non-renewable natural capital is the stuff that does not have that property of life to reproduce itself. We have a rich endowment from which we have created our modern world. Non-renewable natural capital does not go away because we transform it into something else. Energy cannot be destroyed, and hence we do not strictly consume it. Rather, we transpose it into some other form, for example into heat, creating pollution in the process. This is true for all the other minerals too, and it is why we have lots of landfill sites full of the waste products. In theory, much non-renewable natural capital can be recycled, using other non-renewable natural capitals to help recover

and reformulate. But recycling always needs more resources and it is never a closed-loop cycle, as some advocates misleadingly claim.

Because we tend to use stuff once and throw it away, it is helpful to call this non-living and non-renewable stuff. Even if it is recyclable, it cannot reproduce itself. One day, someone might start mining landfill sites, but for the time being most of our wastes are buried. It is one of the reasons why it is possible to talk in theory about running out of certain minerals, and in particular depleting mines and oil and gas wells. Yet even here, the bounty that is our non-renewable natural capital inheritance is so great that there is little we are in fact in danger of running out of, despite the repeated dire warnings. There is enough oil, gas and coal to fry the planet many times over, lots and lots of iron ore, and we are never going to run short of the key building blocks of our modern economies, the cement, steel, petrochemicals, aluminium or fertilisers made from these minerals.

Abundance has in the past meant that non-renewable natural capitals are treated as free (and renewables too, like the cod on the Grand Banks). They have been plundered at will, safe in the knowledge that their supplies are practically inexhaustible. As a result, at near-zero resource cost, natural capital has until very recently rarely seen the inside of an economics or management textbook or been part of finance ministers' economic policies. Without cost, there was assumed to be no resource allocation question that needs answering, and economics is all about the allocation of scarce resources. For the non-renewables, it is not that the resources are limited; rather, it is that their extraction and use can have serious and sometimes dire environmental consequences, and the environment is the ultimate scarce resource. There is, as often remarked, only one earth. These associated costs should be priced – polluters should pay. It will require restraints in the face of abundance to reduce the environmental damage.

Physical Capital, Network and Infrastructure Systems

Out of the non-renewables, vast amounts of physical capital have been created, using bricks, cement and steel made by the application of fossil-fuel energy. The stock of houses has a value in conventional accounts way in excess of natural capital. Houses are the ways many of us hold our wealth. In the UK, for example, the housing stock is valued at £7.56 trillion ($8.7 trillion) as at March 2021. This

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compares with the implausible value placed on UK natural capital by the Office for National Statistics, at £1.2 trillion in 2019.[3] The US housing stock comes in at about $43 trillion (£36 trillion) by comparison. Factories, other buildings, machines, vehicles, power stations, wind farms and solar panels all form part of human-made physical capital. Most of these assets have limited lives, and some very short ones. Much of the physical capital stock turns over on aggregate inside a decade.

There is however one special form of physical capital that lasts much longer. It comprises the core physical system network infrastructures. Think electricity networks, water and sewerage works and pipes, rail and road networks and communications networks. Whilst little effort has gone into protecting and enhancing the natural capitals, government efforts have gone into these physical infrastructures, with most ending up as natural monopolies regulated by, and often owned by, the state. Ensuring their provision has become a core state responsibility. They are crucial assets in the sustainable economy.

They don't usually start off this way. There are very few examples where a state decides that it needs a new system infrastructure and sets about creating it. Typically, instead there is an initial 'wild west' free-for-all, driven by start-ups, entrepreneurs and very much in the Austrian spirit of creative destruction. The most recent examples are fibre networks and electric car charging networks. It starts with invention, followed by local developments and with full integration at a later stage as monopolies form and the state steps in.

Early systems included transport, from roads to canals, ports and railways. Until the late nineteenth century, roads were notoriously bad, and travel involved much time and discomfort. Getting from London to Edinburgh took several days by horse and carriage, and involved overnight stops at coaching inns. Roads had from an early time been provided by military states, the Romans being the stand-out example. Turnpikes, bridges and private roads developed, based upon local monopoly. Modern roads are mostly state roads, though there are many examples of tolled private motorway concessions from the state.[4]

[3] For details of how the accounts are constructed, see www.ons.gov.uk/economy/environmentalaccounts/methodologies/naturalcapital.

[4] For example, after the Battle of Culloden in 1746, the military built roads across highland Scotland to maximise control over the defeated clans.

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Railways grew after the invention of the steam engine, and initially they provided single links between population centres and gradually developed into a mania as investors sought permissions and monopolies over specific routes.[5] As with roads, military considerations were an important influence, notably in the First World War to get the troops and munitions to the front lines. The opening up of the American West was driven by the coming of the railroads. The resulting railways, put together by different and sometimes competing companies, still haunt the rail sector of many countries today, comprise a patchwork of gauges and connectivity, and in many countries have been nationalised.[6]

The absence of adequate systems has led in some cases to the state deliberately stepping in to plan and provide public infrastructure. The London sewers were built in the nineteenth century after the Great Stink.[7] Municipal authorities took the lead on health grounds. Manchester and Birmingham secured water supplies from reservoirs in the Lake District and the Elan Valley in Wales respectively, and all took on waste as a municipal function.[8] To these were added streetlighting and then electrification. For most of Europe these remain a local or regional function today. The exceptions in electricity are France and the UK, both of which nationalised their electricity industries after the Second World War, and created powerful large, integrated companies to plan and deliver the networks to meet the growing post-Second World War demand for electricity. France has renationalised EDF. Water remains publicly owned and locally controlled in most of Europe and the US. The exception is England and Wales, but still at the regional rather

[5] See G. Campbell (2014), 'Government Policy during the British Railway Mania and the 1847 Commercial Crisis', in N. Dimsdale and A. Hotson (eds.), *British Financial Crises since 1825*, Oxford: Oxford University Press.

[6] William Gladstone's attempt to create an integrated railway institution failed. See W. Quinn and J.D. Turner (2021), *Boom and Bust: A Global History of Financial Bubbles*, Cambridge: Cambridge University Press.

[7] There was an intense debate, in which John Stuart Mill took a very active part corresponding with the Metropolitan Sanitary Association, about ownership and the integration of the multiple private water companies in London. This correspondence was published in 1851 as 'Public Agency v. Trading Companies. The Economical and Administrative Principles of Water-Supply for the Metropolis' and is partly reprinted in A.L. Harris (1959), 'J.S. Mill on Monopoly and Socialism: A Note', *Journal of Political Economy*, 67, 604–11. See also N. Tynan (2007), 'Mill and Senior on London's Water Supply: Agency, Increasing Returns, and Natural Monopoly', *Journal of the History of Economic Thought*, 29(1), 49–65.

[8] J.A. Hassan (1983), 'The Impact and Development of the Water Supply in Manchester, 1568–1882', *Historic Society of Lancashire and Cheshire*, 133, 25–45.

than the national level. In all these cases, cities around the world have taken on many of these responsibilities, and especially for water and sewerage.

This piecemeal and bottom-up development of new system infrastructures was repeated for the new communications from the 1980s onwards. The internet developed in an anarchistic and very Austrian way, but gradually the services concentrated around a small number of very large companies, known as 'Big Tech'. What started out as new and exciting technological innovations gradually became general-purpose technologies,[9] and in due course access to the web, email and modern broadcasting became essential. As banking, shopping and government services and welfare support went online, not having access to these new systems became a competitive disadvantage to businesses and led to social exclusion. As with electricity and the railways, the state is now stepping in to complete the new networks and ensure that they are universally available. They, like access to transport, water and electricity, are critical to decarbonisation, and protecting and enhancing natural systems: so important are they, that all have become universal service obligations (USOs). Citizens must have access to them, and the sustainable economy cannot do without them. They are key capabilities and critical to social justice.

Once the initial burst of enthusiasm and entrepreneurship is over, and the systems consolidate, they need a plan, and a set of institutions, private and public, to deliver the plan. Despite the critique of the Austrians and Hayek against the very concept of planning noted in the previous chapter, the infrastructures require a plan for two separate reasons. The first is that these systems are mostly natural monopolies, so there is no competition to discipline them in the Austrian trial-by-markets. The second is that because the rest of the economy depends upon them, there needs to be a precautionary cushion of excess capacity in each system to handle shocks. The precautionary principle starts to bind. The systems have to be resilient, beyond the normal market equilibria. This resilience extends to the protection of citizens, who need to be able to rely upon these systems for their own personal resilience. It is a public good, and will not be adequately provided without intervention.

[9] N. Crafts (2021), 'Artificial Intelligence as a General-Purpose Technology: An Historical Perspective', *Oxford Review of Economic Policy*, 37(3), 521–36.

To these two there is now a third reason for some planning, because the systems are all highways for most of the pollution in the economy. This means that unless the overall environmental objectives of the sustainable economy are designed and developed in ways that facilitate low-carbon activities and the protection of biodiversity, they will not be met. Providing electric car charging points and a grid capable of handling the new electric transport demand and the decentralised, intermittent and low-density wind and solar generation is necessary (but not sufficient) to achieve the overall net zero targets. Providing adequate sewage treatment is necessary for maintaining biodiverse rivers and lakes. The plan may be as simple as a target for fibre coverage, or it may be as complicated as the detailed decarbonisation of energy and transport systems.

Ideas, Knowledge and Human Capital

The third type of capital is human, which has largely replaced manual labour as the stuff that is combined with physical and natural capital to produce economic output. This transition was driven by fossil fuels. The tractors and artificial fertilisers transformed agriculture away from both manual labour and horse power, and digitalisation and robotics are about to take it one stage further, to the point where there are 'hands-free hectares'.[10] This transformation of agriculture, which once dominated employment in most pre-industrial economies, allowed workers to flood into industry and cities, and now as these factories are digital too, labour in the old-fashioned manual sense is increasingly being marginalised.

What people now mostly do at work is apply ideas, science and the technologies these bring, in an increasingly digital way to guide the paths of physical and natural capitals towards the economic outputs. They don't even have to physically go to a workplace to produce outputs. They can work from home, as realised during the Covid lockdowns.

Each generation inherits a body of knowledge and the technologies that go with it, and in the sustainable economy this is one of the capital systems that are passed on. It is typically better than

[10] 'The Hands Free Hectare Project', Harper Adams University, 30 June 2019, www.harper-adams.ac.uk/news/203518/the-hands-free-hectare-project.

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this: each generation gets a better stock of knowledge and technologies. What facilitates the transition from one generation to the next is the provision of education, which has to be continuously passed on because people die.

The stock of ideas and technologies exists independently of any individual, just as natural capital does. It has a life of its own. Passed down through the monasteries and religious schools through to secular schools, universities and now a host of other institutions and websites, it is a key enabling asset to address our global environmental crises. Science allows humans uniquely to understand what they are doing to our planet, and gives them the ideas and technologies to protect it.

Though it is often claimed that it is 'pure' research that does exactly this, and has produced lots of surprises for the benefit of humans, the actual evidence is more nuanced. There is a case for letting scientists come up with whatever they do when left to their own devices, as long as they are provided with incomes and funding for their research and experiments. That is what many of my colleagues at Oxford do. But even that research, pure or otherwise, starts with *questions*, and these questions arise out of two related contexts: the existing body of theory and knowledge; and the specific actual challenges of the sustainable economy.

Take the example of climate change. Current theories and models are the product of centuries of research into fundamental physics, research into the greenhouse gases, research into the atmosphere, data on long-term temperature records going back thousands and millions of years, all to give us the current conjectures on the determinants of climate change. To these physical theories and empirical evidence, centuries of research into energy is added, the innovations and inventions that gave us the Industrial Revolution, and detailed work on specific ways of measuring, capturing and substituting away from carbon-intensive production. Then there is the emerging science and understanding of sequestration of carbon by the seas, and by forests and soils, based on the biological sciences.

The questions that are addressed and which motivate this research are multiple. Climate change brings them together, and the Intergovernmental Panel on Climate Change is a remarkable example of attempting to provide this synthesis and, in the process, throw up new questions and challenges.

Karl Popper, whom we met in the previous chapter, described this approach to knowledge and ideas in a remarkable series of books and papers, most notably in the *Logic of Scientific Discovery* (1934), *Conjectures and Refutations: The Growth of Scientific Knowledge* (1963), and *Objective Knowledge: An Evolutionary Approach* (1972). This body of work is more respected by practising scientists than it is by mainstream philosophers.[11] Be that as it may, the main part of his description of how science works and how the body of knowledge is built up remains revolutionary, and it lends itself to our assets-based and systems approach to the sustainable economy. Consequently it is worth exploring in further detail.

Popper regards the scientific process as starting with the posing of specific conjectures. He does not think that there is any deterministic model of how these come about nor where they come from. In this respect, his approach is very Austrian. Scientists are rather like entrepreneurs, motivated by all sorts of things.

Now Popper's radical bit. Scientists do not try to establish truths; they try to refute conjectures made by others (and by themselves). They are engaged in falsification. All knowledge and ideas are tentative. The task of the scientists is a continuing one of knocking down the old, and making new conjectures that can better capture our empirical world, until they in turn are rejected. It is a scientific version of Schumpeter's creative destruction.

Whilst science does not quite match up to Popper's stringent requirements, and scientists often end up defending existing paradigms, the threat of empirical testing remains powerful. Paradigms can resist, and it takes time to change them and allow for what have become known as Kuhnian revolutions.[12] Whatever the actual processes of scientific discovery, and partly due to the resilience of established paradigms, at any point in time there is a body of knowledge that is still standing, yet to be refuted. That is our current knowledge. It includes the theories of Einstein, after Newton had been found wanting. It

[11] P. Godfrey-Smith (2016), 'Popper's Philosophy of Science: Looking Ahead', chapter 4 in J. Shearmur and G. Stokes (eds.), *The Cambridge Companion to Popper*, Cambridge: Cambridge University Press, pp. 104–24. Popper did not help his philosophical reputation by claiming to have solved Hume's problem of induction. See also A. O'Hear (1980), *Karl Popper*, London: Kegan & Paul.

[12] T. Kuhn (1962), *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press.

includes Darwin, after the creationist theory had been knocked away. And so on.

This body of knowledge is a primary asset, the basis for the economies and societies built up over the centuries. It is the best we have, and it will change over time. It should grow, and hence provide further underpinnings to sustainable economic growth. It is what we inherit and what should be bequeathed to the next generation. It is the chain letter down the generations. We do not need to worry about the generation after next; we simply need to make sure we pass the baton on in good shape. If and as it grows, sustainable economic growth can take place.

There have been dark ages in the past. There have been closed societies, totalitarian ones, which prescribe and try to destroy bits of the knowledge systems, even burning books. The Taliban regime in Afghanistan again reminds us that dark ages are not purely history. Women are denied education. This is the link between Popper's theory of science and his theory of the open society discussed in the previous chapter, and it is a link that Hayek would hold to as well. It is one of the reasons why there needs to be a constitution of liberty, and why totalitarianism is such a terrible threat.[13] It is why many totalitarian societies find it hard to match the innovation and scientific progress of the democracies, and why they are typically so environmentally awful.

You might think that one difference with the approach to natural and physical systems is that the protection and enhancement of the knowledge system and its intangible assets exist in the ether, independently of states and public interventions. On the contrary, without some supporting framework, they will fragment and perhaps fall apart. This is because the knowledge system, and the infrastructure within which new ideas are generated, is a public and not a private good. Private markets do not do much to add to the body of knowledge: they tend to exploit the public goods for private ends, applying ideas in practical businesses. Our understanding of climate change and the ecosystems within which biodiversity is embedded comes from public institutions rather than private companies. Universities tend to be state-driven, as is the funding of much research, even if augmented by private donations. There are examples of maverick, brilliant individual

[13] Hayek sets this out in *The Constitution of Liberty*.

scientists outside this mainstream framework, but they are isolated exceptions.

For the knowledge *system*, recent attempts to apply the economists' cost–benefit analysis to research grant applications is an example of using inappropriate disaggregate techniques. Very few bits of research are separable from the general research endeavour. Whilst there are specific questions which, if we answered them, have specific benefits, most problems are not like this. For example, the development of vaccines for coronavirus led to the new mRNA (messenger ribonucleic acid) techniques, using gene editing, which may translate into specific targeted methods of addressing cancers and help develop a form of personalised medical interventions. They may change crops too. It is very hard to keep any specific bit of research in its box. Because the potential benefits are open-ended, it is particularly damaging to apply crude discounting to them, and hence create a bias towards shorter-term near-market progress. With research, it is rarely clear what the benefits will be, and which to discount. The benefits of scientific advances are forever, open-ended and hence of much greater value than specific projects subjected to cost–benefit analysis. Scientific knowledge is best considered as an asset-in-perpetuity and shares with sustainable natural capital this open-ended property.

Popper described these assets as his *World 3* of objective knowledge, as distinct from the physical universe of World 1 and the human consciousness of experience and thought of World 2.[14] This World 3 body of knowledge could be regarded as the outcome of a process akin to natural selection: the theories which have so far survived the competitive challenge of empirical testing. It is a neat way of encapsulating the system asset which needs to be maintained and enhanced for the next generation, and the source of sustainable economic growth, and hence a critical bit of the architecture of the sustainable economy.

Now contrast this with the economists' approach to human capital. Gary Becker, the great Chicago school economist on all this, described human capital as essentially a discrete investment activity with marginal costs and damages. Each of us 'chooses' how much human capital to acquire on an autonomous basis. We invest as if we are entrepreneurs, looking for profit. We are personal 'factories' built

[14] K. Popper (1979), *Objective Knowledge: An Evolutionary Approach*, revised edn, Oxford: Clarendon Press, chapter 3.

out of this investment, and our acquired knowledge has a capital value, which yields a flow of income, in the form of higher wages. It is an individualised hyper-capitalism in which we are all little capitalists playing out our lives in the competitive marketplace.[15]

As an economic theory, it goes some way to explaining the differential returns in wages to those with university education over those without, and why unskilled and poorly educated people have done so badly in recent decades, notably in the US. Not surprisingly, more education tends to lead to higher productivity and higher wages.[16] But this rather obvious claim only gets us so far. It may be that it is also social position that counts, and educational attainment is the outcome of inequality as much as university degrees. Education can be a screening device. But in any event, it does not deal with the wider benefits of education to society as a whole, or to the incentives to invest in Popper's World 3, which is primarily a public rather than a private good. The body of ideas, knowledge and technologies exists independently of the bits of it that are acquired by individuals. Becker's human capital is really about specific aspects of education and educational choices, not the public good of science. As long as human capital is assumed to be just a set of discrete atomistic investments, human capital decisions are examples of forgone consumption now for more consumption later, in effect part of the allocation of time (the ultimate personal asset).[17] In contrast, the systems public goods approach sees education enhancing not just for the narrow investment decisions but also wider sustainable economic growth because it helps to apply science, and it is the science that is the primary cause of that sustainable growth. Universal education and the development of the primary asset of science are both necessary parts of the sustainable economy.

For both narrow economic reasons and because education provides a core capability, it is not surprising that governments have taken on the duty to provide education, and to largely fund it too. Where it

[15] This is the model Becker developed and which has dominated the economics of education ever since. See G. Becker (1964), *Human Capital*, 2nd edn, New York: Columbia University Press; and D.J. Deming (2022), 'Four Facts about Human Capital', *Journal of Economic Perspectives*, 36(3), 75–102.

[16] See the survey of empirical evidence on human capital in K.G. Abraham and J. Mallatt (2022), 'Measuring Human Capital', *Journal of Economic Perspectives*, 36(3), 103–30.

[17] See Becker's brilliant 1965 paper 'A Theory of the Allocation of Time', *Economic Journal*, 75(299), 493–517, and more generally his *A Treatise on the Family*, Cambridge, MA: Harvard University Press, 1981.

does not, in particular in higher education in the US and increasingly in the UK, the results become highly skewed to the elites who can buy access to human capital and then exploit the benefits.

Social Capital

The fourth type of capital that comes in systems is called 'social capital', the hardest to define, being intangible, and the most difficult to advance. It has long been observed that societies function best when the citizens share a common outlook, a common set of beliefs and a focus on the good of the whole community, as well as on their own short-term self-interests. The sustainable economy cannot work without a fabric of social capital, and one that is well maintained. Religions, national identities and shared cultural histories, with their associated rituals, bind societies together.

There have been many attempts to explain, for example, the coming of capitalism by religion, and to identify the Protestant religion as especially sympathetic to industrialisation and market economies.[18] Correlation – Protestantism and economic growth – does not in itself provide a causal explanation, and social capital is one of those very slippery concepts that tends to get defined in ways that suit those doing the defining. Of the characteristics of a society that might contribute to a successful economy, trust and the respect for the property of others stand out. There are lots of paths in different societies to establishing these core social assets. Contrast Iran with the US, and the US with Germany: very different cultures, but all built into their specific social capital.

Exchange and transactions between individuals always depend upon an element of trust. Markets cannot function without it. Parties engaged in trade must ask themselves: why is the other party selling this to me, or buying it from me? What do they know that I do not which makes the price we agree one each wants to accept? If I sell my house to you at an agreed price, is that because I know it is worth less? The answer is that trade tends to open up possibilities to each of us of

[18] M. Weber (1905), *The Protestant Spirit and the Rise of Capitalism*, reprinted 2002, London: Penguin Books; R.H. Tawney (1926), *Religion and the Rise of Capitalism: A Historical Study*, London: J. Murray; and M.J. Wiener (1981), *English Culture and the Decline of the Industrial Spirit, 1850–1980*, Cambridge: Cambridge University Press. See also B.M. Friedman (2021), *Religion and the Rise of Capitalism*, New York: Alfred A. Knopf.

exchange, specialisation and comparative advantage, and is a vital part of our ability to function and thrive. Comparative advantage suggests that each of us specialises. Some are better at growing and making food than others because they have acquired specific human capital skills, and some have better climates and better access to natural resources than others.

In the case of the house, quite detailed contracts are written to certify what exactly the house is that I am selling. But even when it turns out that the roof is in a poorer state than you were led to believe when you bought the house, enforcing the contract terms is quite difficult. You have to carry an element of trust in the seller, otherwise the contract is going to be immensely complicated. It turns out that most transactions are overwhelmingly based upon trust, built up through repeated transactions. This trust is also based upon the other person being part of a culture in which untrustworthy behaviour is frowned upon, and social conventions ostracise those who behave in untrustworthy ways.[19]

Societies without these shared cultural norms find trade and exchange harder and thus are worse off. Where greed, short-termism and narrow opportunism are encouraged, such as in the yuppy culture of the 1980s, and the 'greed is good', 'loads of money' mentality is promoted politically, productivity suffers. Think of the post-pandemic working-from-home issue. It is harder for employers to monitor what you are doing at home rather than in the office, but working from home cuts your commuting costs and has other benefits. Does the employer trust the employee to be working 9 to 5? If trust is present, there is great scope for high outputs because there is less stress and costs are lower. If not, then working from home is less prevalent than it could be. Cultural norms, such as the German attitudes to savings, are more likely to create (and reflect) social solidarity and understanding.

A second aspect is trust and the limiting of crime (including environmental crime). Markets rely on a prevalence of honest transactions. They rely on us not stealing most of the time, and societies with a greater degree of social capital tend to have lower crime rates and hence have lower costs. Think of how much economic activity is spent on crime prevention. Think of all those locked houses, those passwords

[19] J. Son and Q. Feng (2019), 'In Social Capital We Trust?', *Social Indicators Research*, 144, 167–89.

and protective measures on the internet. In this latter case, the intriguing possibility is that the more remote and anonymous trade is, the less trust and the more scope there is for crime and the higher costs. As the world gets more virtual, this may lead to higher levels of crime. Inevitably, the sustainable economy will be undermined.

At the country level, low social capital helps to explain the economic difficulties of Russia, with its political corruption and the short-termism this induces in its population. It explains why Putin has tried to cultivate the Russian Orthodox Church, to buy into its social capital.

Social capital is a key part of the inheritance of the next generation. There is a reason for the protection and enhancement of the institutions that nurture this form of capital, including education. Social capital is especially important when it comes to climate change and biodiversity loss. The reason is the powerful incentive to free-ride on the provision and protection of these great environmental assets. Whether you do anything to reduce your emissions will have almost no effect on climate change, just as if you vote it will not determine the outcome of an election. The reason is that we are all too insignificant to make a difference. Climate change requires the Chinese, the Indians and the Africans, and your neighbours next door all to simultaneously take steps to reduce their carbon footprints. If any of these people take active steps, you get the benefits (less climate change) and no costs if you make no effort yourself. You have a powerful incentive to free-ride. Social capital leans into the wind of free riders, limiting their impact.

Thinking as a greedy, self-interested individual, why not party whilst others take on the costs of reducing emissions? This scares environmental activists a lot, and for understandable reasons. If each of us realised that this free-riding incentive is sufficiently serious such that it is very unlikely that we will collectively head off significant climate change, and if it turns out to cost us individually quite a lot to do our small contributing part, then even if we are not ourselves selfish, it is not hard to conclude that we should not bother to act in a hopeless situation. Why bother either if some others are not, or if no one else is bothering? In neither case will your action make any difference. This gives environmentalists an understandable urge to tell an optimistic story, to say we can each make a difference and that it will not cost much, even if it is not true. Indeed that is what is going on.

But it is not working, though the manipulation of the media has led to many actually believing they can make a difference and that the costs are low, despite the evidence to the contrary. The alternative is to fall back on social capital and in particular the shared ethical outlook, to stress that 'we are all in this together' and we have to act collectively in the collective interests. This demands that we both recognise the free-rider incentives and yet suppress our narrowest self-interest for the greater good. Getting people to do this depends upon whether they do in fact see the world this way and see themselves as part of a cohesive society, and hence whether there is enough social capital. It is the sort of 'togetherness' that enables countries to fight wars, for the young (predominantly men) to sacrifice their lives. It is the social equivalent of 'team spirit' that motivates a group of sports players to work together, even if it reduces their own personal chance of scoring a goal.

Social capital is acquired from parents and schools, and from the media. All of these in turn grow out of the history and culture of the society, and it is for this reason that these parts of education are especially important aspects of the capital assets we should pass on to the next generation. What matters in the absence of religions is that there are rules which govern our behaviours and the way we treat each other and the wider environment. In the sustainable economy, the overriding rule is set by the first principle, that it is our duty to pass on a set of assets at least as good as we inherited, and that this is embedded in institutions. It is a reason to treat radical institutional reform with scepticism, especially since such institutions (and any radical new ones) take generations to build up. Institutions, like social rules, need to evolve.

The sustainable economy is made up of the four capital systems: natural, physical, human and social. These systems are what we should pass on to the next generation. They are what the aggregate rules derived from the first principle require us to maintain and enhance.

But how to do this? The next step is to shine the torch on the state of these assets, to understand the sorry state some of them are in and work out how to maintain and enhance them where appropriate. To do this we need a balance sheet and some accounts.