

## **Business and Sustainable Development Commission**

Innovation Report

### **The Five Sects of Innovation**

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Innovation will be essential for the Sustainable Development Goals to be met.

Innovation is the search for better recipes to combine resources in new and more effective ways, to meet people's needs and so to create value.

The laptop being used to write this paper weighs much less than one ten years older and yet it is more than 100 times more powerful. Many of the physical ingredients are little different. The improvement in performance stems from the minute rewriting of the ways the physical ingredients work together. Innovation is that process of finding better recipes to combine our resources more effectively.

Occasionally innovators are inventors who come up with entirely new ingredients to throw into this mix: a new material such as graphene for example. Sometimes radical innovators create entirely new markets: digital mobile devices and communications platforms such as Instagram and SnapChat. More often innovation involves reorganising how we use the materials we already have to create better solutions. Often innovation does not involve technology that is new, but the inventive adaptation and reuse of old technology: radio and corrugated tin are good examples. Innovation is invariably a lengthy, collaborative and cumulative process of overcoming not just technical challenges to make something work but organisational and cultural ones as well. Innovation is never just a process of engineering a new product; it is always also a process of

working out how to make and market products, so consumers get solutions they want and businesses can make enough money in the process to sustain themselves. That process is invariably a team effort, involving people with many different skills, collaborating within and across organisations.

The Sustainable Development Goals will only be met if more people get solutions they want which work within economic and resource constraints. That is only possible with more innovation, in more forms and from more people and places. Yet promoting more innovation on its own will not be enough.

We need innovation that creates new and more sustainable systems of production and consumption. Innovation that stimulates economic growth by using product proliferation to encourage rich consumers to consume more will not do the trick, indeed it may be destructive. Innovations that create cheaper products and services but thereby encourages more demand for energy and resources per capita will not work and could be counter productive. Instead we will need innovations that deliver a better quality of life, to more people, while using fewer resources: transformative and generative forms of innovation.

That will require more than new products and services. We will need new systems, which underpin how we use water and energy to grow food, make things and dispose of waste. Water filters that make dirty water drinkable are helping families all over the world. Yet the best solutions are systems that provide families with clean water in the first place. Solar powered lamps help people who lack electricity to cook, work, read and study after dark. Yet the best solutions are energy systems that deliver cheap, renewable energy often from local sources to light up networks of villages.

To break out of a period of low, increasingly unstable and unsustainable economic growth, which is bringing in its wake rising inequality and conflict over migration, we need waves of investment, both public and private, in new systems to meet basic needs for housing, energy, education, health, communication, mobility. Business will play the critical role in leading the

transition to these new systems, not least because it will have so much at stake in their success.

Many businesses are well schooled in product development: producing new televisions, cars, computers, deodorants and phones. Many excel at incremental innovation to increase productivity. The challenge of the future, however, is to create new systems that deliver entirely new ways for citizens and consumers to meet their needs. That will require collaborative innovation to build alliances of partners, suppliers, customers, regulators and even competitors adopting more efficient way of working. It also involves the commitment of substantial amounts of capital, usually public and private, often in overlapping waves as different obstacles are overcome, systems expand their reach and old approaches are decommissioned. Dislodging older, entrenched systems is often the biggest challenge.

Yet the gains for business from creating these new systems will also be huge as they unlock entirely new ways to meet mass needs and so earn rewards. Creating systems that serve society with better solutions is the main job of modern business. By doing so business will also provide society with a narrative of hope which will underpin trust in business. The prospect is for a far more broadly spread and sustainable pattern of economic activity, one that will provide business with a solid foundation for growth, people with employment and income and better products and services for their homes and families. The foundations of the current economy are growing increasingly shaky; more innovation of the wrong kinds may make them even shakier; we need innovation which will create more stable, sustainable foundations.

Evidence from previous long-waves of investment and innovation suggest that when economies get stuck – as many are now – in a period of low growth, they need new systems of production and consumption, business methods and lifestyles to kick start growth. That is what happened with the rise of electrification, mass manufacturing and automobility in the mid 20<sup>th</sup> century which gave us new ways of living and producing, organising and producing. We

need a similar process now, which creates systems that work in very different ways, which provide a sense of collective agency and control but which also engender trust and a higher quality of life.

In the 20<sup>th</sup> century industrial capitalism used more resources than had ever been used in human history – coal, wood, iron ore, oil, water – to create more products for more people and yet at the century's end prices of basic resources were 50% lower than they had been in 1900. We will not be able to pull off the same trick twice. The resource intensive capitalism of the last century may well lead us to disaster and conflict in the century to come. The outstanding recent development success story, the Chinese model of rapid development through industrialisation and urbanisation which has lifted many millions out poverty may well have reached its own limits in terms of environmental and social sustainability. As Pope Francis pointed out in his recent encyclical on the environment, *Laudato Si*, we will only address the environmental challenge if the entire economy works differently. To make that possible business will have to innovate new forms of organisation and ownership, responsibility and rewards: a new corporate social contract. We will need to flip the system.

We have lots to work with. Five different trajectories of innovation will help take us to a better future. Each offers huge opportunities for business to create the new basis for sustainable shared prosperity. Each is advocated by a sect of believers.

## **The Five Sects**

### **Exponentialists**

The Exponentialist sect believe radical scientific and technological breakthroughs will create new technologies to enable abundance: low or virtually zero cost solutions to basic needs, provided by distributed technologies which will re-programme material and natural processes, from the bottom up.

These technologies will release us from the resource constraints of clumsy and crude industrial processes to allow us to leapfrog to new ways to meet needs far more effectively. That leapfrogging should be easier in the developing world, where industrial age systems are less entrenched and where the technologies are most needed.

The most famous Exponentialist is Ray Kurzweil, the futurologist head of engineering at Google and co-founder of the Singularity Institute. Kurzweil predicts there will be a “singularity” when machines become as intelligent as humans. Machines will carry on becoming more intelligent, however, outstripping humans. As a result humans have little alternative but to rely on integrating machine intelligence into human intelligence: thus the new singularity, a new form of combined human and machine intelligence. Peter Diamandis applies much of the same thinking to products and services in his book *Abundance*, a super-optimistic account of the potential for new technology to create circular, low waste systems to release us from material constraints.

Nick Bostrom, the Oxford based analyst of existential risks, is also an Exponentialist. His book *SuperIntelligence* is about the impending explosion of intelligent, self-managing machines, which could take much of the running of the world from humans. Ubiquitous artificial intelligence and machines capable of rapid learning will allow most routine and many non-routine jobs, including surgery, teaching and managing, to be done by intelligent machines. Intelligence will be super-abundant. Bostrom, however, takes a far less benign view of the

potential threats from artificial intelligence, worrying not just about the displacement of human labour but also the possibilities of machine induced catastrophes.

Exponentialists forecast huge improvements across many of the areas covered by the SDGs. To cure climate change plant cells might be redesigned by synthetic biology to feed off the carbon in the atmosphere. To improve health care at source, nano particles might be impregnated with the technology to seek out disease within the body thereby extending lifespans and reducing the costs of hospital systems. In future we may be able to use a combination of 3D printing and synthetic biology to print skin which will graft itself onto us. New tissues and organs could be grown to order. Neuroscience will soon unlock how to do much the same for brain cells.

To meet basic needs, for example for housing, new forms of concrete, the world's most ubiquitous building material, are being developed which can be cured without using water but instead by sucking carbon from the atmosphere, creating a cheap building material that conserves water and acts as a carbon sink. As for energy, small-scale wind turbines, that use a shroud to circulate air around the turbine offer the possibility of ubiquitous and reliable wind power. When these high tech, mini-utilities are networked together they could create a new wind powered energy network. That will be combined with rapid advances to create cleaner, safer, cheaper non-chemical batteries using new plastics.

Exponentialist innovation is not just about products and services but entirely new systems and platforms that could allow us to meet human needs in entirely new ways, from atomically precise manufacturing which will provide new ways for us to make things and to blockchain technologies which will allow us to rethink money and banks.

## **Atomically Precise Manufacturing**

Eric Drexler is a visionary engineer who believes modern manufacturing, even in its latest lean incarnations, is still prodigiously wasteful and inefficient compared with biological systems which use local resources, renewable energy and leave behind little waste. Drexler, who made his reputation as a seer in the 1980s by bringing nanotechnology to popular attention, believes we are on the verge of a new industrial revolution, which he calls atomically precise manufacturing (APM). This would take the nascent decentralised maker movement to an entirely new level of scale and productivity: a development that Jeremy Rifkin has called the third industrial revolution and which is being actively explored by policy-makers in China.

The best way to understand atomically precise manufacturing is to think of it as a bit like printing. A modern printer can translate a digital image from a computer into a series of pixels and then printed dots which create a physical replica of the digital original. Now imagine you could print off virtually any object you needed by first downloading a design and a recipe for its production, and then rearranging commonly available materials – carbon, hydrogen, oxygen, nitrogen – to make any material you needed. Atomically precise manufacturing would depend on our being able to reorganise materials from the inside out, reprogramming their molecular bonds, to create a variety of new materials from a few basic building blocks. Basic protein molecules are made up of 20 different kinds of monomers, strands which form their most basic components. The same basic monomers mixed in different ways can be found in soft rubber and hard plastics, in super strong spider silk and rhino horn. Imagine we were as clever as the mussel that can make its own hard shell without intense heat and attach itself securely to a rock while under water. If our manufacturing systems were that clever we could make a huge variety of objects out of the same basic set of materials without needed to forge, blast, sear or melt them.

Drexler argues that we stand on the verge of abundance: we could make virtually anything we want, out of common materials found locally, at very low cost, using renewable energy and leaving little waste. Lengthy, costly, energy-intensive

supply chains would be a thing of the past. Old products could be broken down and reconverted back into the basic chemical feedstock needed to make new products. This would be a manufacturing system modelled on biological and chemical principles. We could have anything we want and yet still live lightly.

Imagine a solar array being printed like a sheet of aluminium foil, or material as strong as steel being produced but without the blast furnace and the rolling mill. If APM machines were as widely spread as say mobile phone shops, product designs were available open source and basic feedstock materials abundant, then millions of people could be lifted out of material poverty at low cost, using environmentally sustainable processes that require no transport.

### **Block Chain**

Just as Atomically Precise Manufacturing offers a molecular remaking of manufactured items from the bottom up, blockchain technology offers to do much the same for money. APM offers the prospect of ubiquitous, low cost manufacturing; blockchain offers the prospect of ubiquitous, low cost financial systems using technology rather than banks as the intermediaries.

We are used to the idea that money is controlled by states and especially by Central Banks who have the right to print it. We are also used to the idea that most financial transactions - being paid by your employer, paying for your rent, buying a latte - goes through a trusted intermediary like a bank. The bank keeps tabs of all the transactions, through various ledgers and registers. Each month we get statements of our accounts which tells us where our money is. These statements in aggregate would tell society where all its money is. Money is in one sense no more than a way to make these various ledgers and registers of trades and transactions add up. We use the banks to look after all of this for us.

Blockchain technology is potentially disruptive – and exponential – because it provides a completely different way for this reconciliation of ledgers and registers to take place and so for us to organise money. Instead of a bank looking after the process, it is handled by an open, shared, transparent but ultra secure



process of creating “block chains” of transactions. Each transactions, mapping a movement of money, has a piece of computer code attached to it; each piece of code tracks some money; that allows everyone to see what everyone is paying everyone else. In theory no one needs a bank anymore: transactions could all be peer-to-peer and secure, using this technology.

Block chain could be hugely significant for the achievement of the SDGs. While 5bn people lack access to affordable and trustworthy financial services, which in turn limits their ability to access markets, about 2bn people have mobile phones, many of them smart phones. Using those phones it should be possible to create secure peer-to-peer systems for people to make payments to one another and beyond that more sophisticated financial services, such as loans, insurance, savings, mortgages and corporate finance. M-Pesa in Kenya is a simple version of one such system. Many more may follow in its wake.

By allowing trusted financial systems to be created at very low cost, the distributed, secure and shared technologies of block chain could offer liberation to millions of people who find it hard to trade, buy, sell, save, insure, borrow. Moreover the attractions of these technologies are even greater in states which are fragile or corrupt and where the state’s backing for money is most in doubt. Many of the people who would most benefit from the achievement of the SDGs live in countries which need financial systems immune from corruption and state fragility.

Blockchain offers the possibility of banking without banks, exchange without money, a radical remaking of the market economy.

## **Conclusions**

Exponentialists are visionaries and iconoclasts. They look beyond industrial age systems to see entirely new ways for us to satisfy our most basic needs for food, energy, material goods, money and knowledge. They are by turns unsettling and inspiring. They tend to be so at odds with current, conventional thinking and work in blue sky labs, sometimes in universities and foundations, often at tech

companies, often cut off from the constraints of the real world. They aim to create entirely new systems by going down to the molecular level, remaking products and systems from the bottom up and inside out.

Exponentialist innovations like atomically precise manufacturing and blockchain systems could bring enormous benefits to many hundreds of millions of people who do not have access to heavy duty industrial era systems for manufacturing or finance. Moreover, these new systems might be easier to create in the poorest parts of the world precisely because these places are not encumbered by the entrenched systems of old. That is one reason Exponentialist innovation could have such relevance for the SDGs.

Of course there are also significant uncertainties, downsides and limitations. As many of these innovations are emerging from labs in the rich, developed world, they can be open to accusations of elitism. Their success could feed further concentration of wealth and power. Exponentialists tend towards highly libertarian views; they are at the very least sceptical of government's contribution to innovation if not hostile to it. They tend to believe a mixture of high technology, competition and open markets will bring the best results. That does not always make them easy partners. Exponentialist predictions of a coming singularity, the merger of human and machine intelligence, moreover might be precisely the wrong direction of travel. If the world needs more people, solving more problems in more places we might be better seeking a growing plurality and diversity of approaches, including forms of intelligence, knowledge and wisdom. Finally, there are the warnings from Exponentialists themselves that living with abundance might turn into a nightmare as humans find themselves increasingly in thrall to machines that are more intelligent than us.

## **Smartists**

The Smartist sect argue that significant improvements in productivity (most importantly resource productivity) will come from making inherited industrial and especially urban infrastructures more intelligent, adaptive and productive. Industrial era solutions are wasteful and inefficient because they are dumb; the solution is to make these systems smart.

Smartists believe information and intelligence are the key constraints on productivity. Too many of the systems we rely upon for energy and health, water and food are needlessly inefficient because they are so ill informed and poorly coordinated. As a result resources are too often misallocated, lie idle or go to waste.

The solution lies in using waves of digital technologies, especially a combination of Big Data and the Internet of Things, ubiquitous and connected computing power, remote sensors and artificial intelligence to create far more informed, adaptable and productive systems.

In the industrial era, material production processes – for example in factories - generated data that was then analysed to modify the processes. In post-industrial, networked systems data and algorithms are in the driving seat, reconfiguring real world systems to make them more efficient. Advocates of smart solutions argue, we can create properly coordinated systems out of activities that at the moment are disconnected, poorly aligned and so collectively inefficient. (One inspiration for the Big Data movement was a doomed attempt to create a computerised planned economy in Chile.)

These platforms and networks will allow solutions to be assembled to basic needs often without much human intervention. Airbnb, Uber, Facebook, We Chat and Alibaba are just the first, examples of these platforms, which allow supply and demand not just to bring one another into existence. The next stage will

digitally autonomous enterprises which organise production, payment, shipping and distribution almost automatically.

Airbnb creates a new supply of places to stay – people’s spare rooms - which in turn unlocks new demand, which in turn drives the scale, diversity and quality of information of its platform allowing people to make better choices. Uber brings into being a new way for under-used assets – private cars – to be used to ferry people around a city, connecting those who want to offer rides to those who want to take them in new ways. Uber has created on demand ride sharing service by networking together previously disconnected assets, drivers and consumers. It has created a new system almost on the fly by reconfiguring existing ingredients to work together.

Cities, a key focus for the Commission and their achievement of the SDGs will be the main theatre of operations for these smart systems.

### **Smart Cities**

Cities are becoming digitalised, overlain with a skein of apps and software that will allow people to navigate them and use their available resources far more effectively. One example is the city of Rio de Janeiro’s alliance with the transport app Wayze to create a real time transport map of the city to inform both the city authorities and drivers. Another example is the way the Bangalore start up MapUnity has enabled citizens to assemble bottom up a real time transport map of the city by networking their mobile devices together. MapUnity’s community has been using its own data to drive the development of new railways services, making better use of existing lines and rolling stock.

The most basic industries, such as agriculture, are becoming increasingly digitalised and so open to smart solutions.

### **Smart Agriculture**

Global food production will have to increase by 70% by the year 2050 to meet the needs of a population which will grow by more than 2bn to 9.7bn today. Yet

crop yields have largely plateaued and most land suitable for agriculture is already under cultivation. Traditional methods will not meet the growing demand for more and better food. Food is essential for life and so vital for politics as well. Sudden rises in food prices are a key trigger for political discontent especially in fragile states.

Agricultural productivity could be remade through Smartist innovation. Take a cocoa farm in Nigeria as an example. Sensors in the ground would monitor the moisture and the soil make up. The data from these sensors would trigger computer controlled drip irrigation systems that would deliver precisely calculated amounts of water direct to the plant roots. The plants themselves might well have been genetically edited, to ensure they are well tailored to the conditions and to grow as productively as possible. Drones might fly over the farm scanning for weeds and areas of low growth, allowing more fertiliser and water to be delivered where needed. All that information combined with long term weather forecasting would tell farmers when it is best to plant and then to harvest their crops. Those decisions would be informed by predictions from markets for commodities and final products to ensure farmers maximise their yields. An individual farmer might once have decided which crop to plant when based entirely on tradition. In future they could take those decisions with the help of dense information systems: algorithmic agriculture.

Smart systems should also allow food to become more traceable. Quite soon a consumer should be able to ascertain where their food has come from not just by using their smart phone to scan some data from a label but directly to analyse the contents of the food. Consumers better informed about where their food has come from, at what environmental and social cost, should be in a better position to drive change in supply chains, to make them more sustainable. Better data in the hands of consumers should drive better decisions.

Were this combination of Smartist innovations to be applied across food chains as a whole, better coordination could yield massive benefits. If food waste were a country it would be the world's third largest producer of carbon emissions.

Simply cutting waste in current food systems would help to make up quite a lot of the projected 2050 food production shortfall.

## **Conclusions**

Smart solutions will help us remake the physical world, from power systems to hospitals and cities by applying our collective intelligence to make more of our combined assets and resources. In important ways the world the Smartists envisage is more personalised and more efficient but only because it is also more social and collective, relying on the collection and analysis of data in real time.

Part of the attraction is that while smart solutions rely on exponential improvements in computing and artificial intelligence, they do not involve completely disruptive, revolutionary innovation in the real world. Smart solutions do not write off current systems so much as transform them. Farmers will still grow crops but informed by smart systems. Energy systems will still use gas and boilers in our homes but controlled and monitored remotely by intelligent systems.

One of the costs of more efficient “auto-pilot” systems is that they can eliminate the role of human judgement which especially matters when there is a crisis or if you want your service delivered with a human touch.

Companies large and small, young and old, will play the critical role in creating these new systems. These new smart solutions are emerging from established companies trying to renew their business models, to insurgent start ups to large technology conglomerates such as Google.

However these systems will only come about through innovation not just in technology but in how companies organise themselves. For farms to become smart, farmers will have to become reliant on wider systems of information and analysis, provided by software platforms. Much of the value and power will lie in these software systems and their ability to drive higher performance rather than in the white box on the wall or the farmer’s field. Companies will only create

these new systems if they are prepared to remake themselves. New technologies which allow much greater traceability and transparency about how products are made, where and by whom should allow much consumers to drive change through their own social preferences. Smart systems should enable that consumer power to have more influence.

## Frugalists

The Frugalists argue for bottom up, real world problem solving, often using adaptations of tried and tested technologies, by people with limited incomes who face enormous constraints in achieving their aspirations.

Frugal innovators use tight constraints to drive radical rethinking: they have to find a way to provide health care, education, food, energy at very low cost. Amazon has radically rethought the business model of retailing by eliminating core costs – people and stores. Frugal innovators do the same not out of choice but necessity and without the benefits of cutting edge technology to help them. Frugal innovators use traditional and borrowed technology to achieve breakthroughs.

Frugal innovation is emerging from India, Africa and Latin America. Frugal innovation draws on many sources and inspirations, from local indigenous knowledge and networks, to the philosophy of EF Schumacher's *Small is Beautiful*. The business opportunities of frugal innovation were identified by for C. K. Prahalad's groundbreaking work *The Fortune at the Bottom of the Pyramid* and the pioneering *Jugaad Innovation* by Navi Radjou, Jaideep Prabhu and Simone Ahuja which explored frugal innovation in India. Now across the developing world many different solutions are emerging to meet the needs of people who cannot afford costly industrial and professionalised solutions.

Many of those solutions are adapting mobile phones and their networks to create everything from a payments infrastructures to a test for anaemia. A resurgent do-it-together movement of makers, hobbyists and craft producers is spreading thanks to the low cost, Arduino mother board, the Rapsberry Pi computer and cheap 3D printers. Frugal innovation is done on the ground, in real time, with real consumers: that way innovators have to use widely available cheap resources at hand which means they solutions they come up with have a chance of scaling to other resource poor settings. They have to test out their products



with real consumers rather than going through lengthy, lab based design processes.

Frugalists make tight constraints work for them by using them to turn conventional business wisdom on its head. They make the most of marginal markets, overlooked by large companies and where resources are scarce, to rethink traditional, costly, top-heavy business models. Frugal innovators eschew cutting-edge technology. They prefer to do radical things with proven, technologies, which are known to work, familiar to consumers and easy to maintain. They excel at innovation as a process of 're'-thinking rather than as invention: they recycle, reuse, repurpose, remediate. They cannot abide waste in any form. That is why they are disciples of the lean thinking first developed by Toyota in the midst of the crippling crisis that gripped the company after the Second World War. They follow the principles of natural circular systems because they cannot afford to do otherwise. They prefer simple self help solutions – like the Mexican social business Echale Tu Casas' self-powered brick making machine - which can be transported to a village on the back of a pick up truck. A village can learn how to use the machine in a matter of minutes and within a few days produce enough bricks to build 15 houses, using just local soil mixed with a little cement. A prime example of these principles in action is Husk Power Systems in India which uses an old technology – biomass gasification first used in WWII when petrol was expensive – to create mini utilities powered entirely by otherwise worthless discarded rice husks.

Frugal innovation is at its most powerful when it created entire systems that are frugal, from start to finish, rather than standalone products. One example of frugal systems are the health care systems emerging in the developing world. Another is the way that some frugal cities are managing food and water.

### **Frugal Health Care**

Dev Shetty has created the world's leanest low-cost heart hospital, the Narayana group, that provides heart operations at a fraction of the price of those in the developed world but at higher levels of quality. Shetty did this by rethinking the

process of heart surgery as a lean system in which surgeons work in a theatre with two tables. Once a surgeon has finished with one patient they turn around to start on the next who is already in place and anaesthetised. The entire system, end to end, needs to be designed as a flow. By designing a system to maximise the efficiency of the scarcest resource, the time of surgeons, Shetty has managed to deliver heart operations for less than a tenth of the price in the US.

The most ubiquitous frugalist technology however is the mobile phone and especially in health care.

Medicall Home, in Mexico city, is a mobile phone-based primary healthcare system used by 5 million Mexicans and which costs them just \$5 a month. Health care in Mexico is expensive and difficult to access. The public system involves long journeys and queues. Medicall Home circumvents that by providing people with top quality advice over the mobile phone and then giving them access to a range of services – from testing to physiotherapy and pharmacy at discounts of up to 50%, which is negotiated thanks to its combined buying power. It is in effect a national, primary health care service based on the mobile phone network.

### **Frugal Cities: Water and Food**

Singapore is the model frugal city. In the early 1960s Singapore's survival was threatened by water shortages of the kind that now overshadow many cities in the world. Severe droughts forced widespread rationing of household supplies and limited industrial production. Singapore's basic water infrastructure had been installed in the late 19th and early 20th centuries by British engineers who dammed-up streams and built reservoirs and municipal waterworks. As Singapore's economy grew so the land taken up for clean water catchment for the reservoirs became more commercially valuable. Expanding the water supply using traditional technologies was impossible. Singapore was at an impasse.

One part of the solution has been investment in new technologies for desalination. Singapore is surrounded by the sea. Desalination has been a part of

Singapore's water strategy since the 1970s but the energy costs involved always weighed against it. Desalination can also leave behind a destructive, highly concentrated brine. In 2005 a new desalination plant was commissioned using the latest in reverse osmosis technologies that allow fresh water to be produced at low temperatures, with minimal energy and limited side-effects.

Yet most of the strategy has turned on simple, systematic and frugal solutions. Singapore gets more than double the global average rainfall but most of it used to wash away. Singapore set out to turn the city into a water catchment system feeding rainwater into a network of localised reservoirs and tanks which are hidden beneath school playing fields and motorway flyovers. They are connected through a computer-controlled system of tunnels and pipes. To make sure the water flowing into these tanks is as clean as possible, the authorities led an attack on sources of industrial and household. One reason Singapore keeps its streets clean because that is where its water comes from. The city is its own reservoir.

Another frugal approach was the NEWater strategy launched in 2002 which aimed to recycle as much industrial water as possible. Recycling water has a powerful multiplier built into it. When one drop of clean water is recycled it can create half a drop of clean water. When that drop is recycled it creates a quarter of a drop. If this process of recycling is continued a single drop of water can eventually produce another drop. In Singapore recycled water is mainly used in industry and for domestic use (such as for flushing toilets) but not for human consumption. That decreases demand on Singapore's very precious supplies of truly fresh water. The first large-scale recycling plant was set up in 2002 and ten years later this was supplying 30 per cent of Singapore's water demand. Recycling has halved the reservoir capacity Singapore needs.

Singapore shows that frugal innovation to make the most of scarce water supplies should be at the heart of a modern, urban sustainable economy. Like all frugal innovators Singapore used the tight constraints it was working under to its advantage to trigger a search for solutions that turned conventional thinking

on its head. Since 1994 Singapore's economy has grown by about 5 per cent per annum, its population growth has been 2.2 per cent a year, but water demand has risen by only 1 per cent.

Providing growing cities with food remains one of our biggest challenges, not least in terms of energy and water usage and carbon emissions. Many people think that cities of the future will need to grow more food close to the city, not least to cut down on food miles. After all that is how many cities fed themselves.

A modern version of a city fed by urban market gardens can be found in a marginal city, outside the mainstream, which faced a crisis threatening its future: Havana.

Cuba suffered a profound shock when the Berlin Wall fell and the safe Soviet Union market for its sugar went up in smoke. The US trade embargo meant that Cuba found itself largely isolated in the world economy and with large industrial farms which no longer had export markets. The decline in Cuba's foreign earnings meant they could not import food as it once had. In 1989 the average Cuban was eating 3,000 calories a day. By 1993 it was closer to 1,950. Yet Cubans then responded by starting to grow food in new ways, on small private farms and in thousands of pocket-sized urban market gardens. They could not use imported fertilisers so these small farms were de facto organic. In Havana alone there are more than 200 *organopicos*, urban gardens, on formerly vacant lots, which employ local people to grow food, supported by a network of specialist agronomists. Across the country there are thousands of these local, cooperative urban gardens. Thanks to the extreme conditions of its isolation, Havana has created the world's largest model for a semi-sustainable, urban, organic agriculture which uses only limited amounts of energy, oil and chemicals.

Singapore is a city that largely waters itself; Havana is a city that largely feeds itself. When these two models are combined, the clean, low-cost ways of growing food for cities in cities become a real possibility.

Frugal solutions are lean and simple, clean and social. They depend on people collaborating, in cities like Singapore and Havana and the villages served by EChale tu Casas and so often have the added side effect of generating social capital. They tend to be human scale innovations, which means they overlap with the four pathway of innovation.

## **Humanists**

The Humanist strand of innovation challenges us to rethink what good outcomes are. Rather than focus on measures of GDP or listing consumer durables that we can buy with our income, Humanists argue we should focus on what most matters to making people happy and fulfilled, from doing satisfying work to having supportive relationships. Rather than measure the good life in the terms economists use - productivity, income and GDP - the Humanists urge us to look at the economy through the lens of what most matters to people: safety and happiness, well being and freedom, having a secure sense of identity and belonging.

Three forces will promote this Humanist rethinking of what innovation should be for.

The first is that as societies become richer and they meet basic needs more effectively, so the focus for households shifts to achieving a higher quality of life, often in the form of services – health, education, care, communications, entertainment, leisure – which are both human and relational. These human measures of progress are the most compelling for many people. In ageing societies care for the elderly will become more important. In younger societies the focus will be more on education and developing human potential.

The second is that in a society awash with artificially intelligent machines capable of rapid learning, many millions of people doing routine work, as part of an industrial process, will find their jobs are under threat. This cornucopia of abundant intelligent technology is already creating a pressing challenge of finding a role for paid human labour in the future. What will we do and how will we earn our livings when the robots are doing everything so efficiently? How should we design technological systems to enhance human life rather than displace humans from work?

The third is the way that culture, technology and necessity are pushing and pulling people to experiment with alternative models of economic organisation which are built around self-employment, entrepreneurship, cooperation, collaboration and sharing. Humanists tell their own story of abundance based on our capacity for empathy, community and collaboration. As the economy gets more systematic, so the very human capacity for empathy and fellow feeling will become even more important.

### **Education: From Following Instructions to Solving Problems**

This humanist approach opens up a huge agenda for innovation in a number of areas, not least education which business is already engaging with.

In a more fragile, contested, volatile and uncertain world, driven by innovation and entrepreneurship, we need to equip young people to find and solve problems of all shapes and sizes. The world no longer rewards people simply for what they know, nor because they have good exam results. What matters is what you can do with what you know, working with others to solve often complex problems.

Around the world business is leading the debate over what education should become to equip young people for a more open, innovative world in which our capacity for creativity and collaboration will be vital. Education will need to develop creative, critical thinking and collaborative skills, and build vital attributes such as curiosity, courage and resilience.

We need to learn how to become more human even as society becomes more technological, to become more creative as work becomes more programmed, to be more empathetic as systems become more pervasive, to take the initiative rather than meekly follow instructions, to work together rather than go it alone, to learn how to craft solutions which are bespoke when standardised solutions can be delivered by robots.

We are not robots. We need to excel at being human. That is why we need our education systems become more dynamic to allow more students to develop the basic human capacities to care, empathise and to create.

### **The Future of Work and Income**

Business also needs to lead us into remaking what work is in the 21<sup>st</sup> century. As people seek to make their livings in ways that give them a sense of meaning and control so they are increasingly likely to turn to forms of social entrepreneurship: work that provides them with autonomy and roots them in a community somewhere between the market and the commons, involving both exchange and barter, ownership and sharing. A critical factor is the falling cost of capital: it is becoming easier and easier for people to set up in business on their own or in small teams using digital technologies. Smaller organisations can now find collaborators and partners, customers and suppliers much more easily. The future of business, in other words, might be to create platforms for this mass, entrepreneurial economy to flourish: a return to small scale but highly connected, human scale production.

A final challenge posed by the Humanists, which will keep resurfacing, is the link between income and work. If we want to raise incomes, especially at the bottom of society and if incomes from work become more precarious, thanks to growing competition from cheap robots, then the question of where people will gain a secure and decent income from will become more pressing. That question is leading cities and governments in Canada, Finland and Switzerland to experiment with the introduction of a universal basic income, linked to a massive increases in volunteering, access to vocational education and social entrepreneurship. Most studies show that basic incomes do not undermine the work ethic but instead encourage people to study in order to get better paying jobs. Aspects of basic incomes have been introduced in Brazil – as the cash transfer *bolsa familia* programme. The idea attracts support from the left on grounds of equality and from the right on the grounds that it would radically simplify tax and benefit systems. The UK Royal Society of the Arts is leading an effort to bring together what is becoming a global movement to explore the



applications of a basic citizen's income. Business should have to engage with this debate, especially if high tech, exponential and smart innovation leads to a large displacement of labour from industrial systems.

Innovation is a vital source of hope for people. Many have had their lives immeasurably improved by new products and services, especially mobile phones. However the advent of artificial intelligence threatens many millions of people doing routine jobs. Business cannot lead society to innovative solutions to challenges if it does not acknowledge these fears and help promote human scale solutions. As John Markoff argues in his book *Machines of Loving Grace* one of the most important challenges for business will be to decide how to design technological systems. One school of engineering and technology design favours perfecting artificial systems to make them as efficient and powerful as possible. Another school of human centric designers favour systems which are designed to augment humans rather than replace them. Developing these kinds of systems, however, requires not just conscious design choices but also companies that are prepared to forego some of the profitability gains that might come from a fuller application of more efficient technological systems. One of the key questions for the future then is when and whether as a society we are prepared to turn our backs, at least to some extent, on the apparent gains in efficiency offered by new technologies in favour of solutions designed to maintain a significant human contribution.

## Statists

Innovation is widely associated with dynamic and flexible market economies that are great laboratories for finding new and better solutions. Government is often derided for being slow moving and cautious. When did a government last come up with anything as useful as Google maps? Statists believe that government is vital to innovation, in ways that often go unrecognised: modern mapping systems rely on a public innovation, the satellites that enable GPS systems.

Statists do not dispute that markets are central to innovation. They point out that markets rely on states to create the framework for intellectual property law for example and to invest in human capital and research. Yet they go beyond that to argue that states are important innovators in their own right: under some conditions and for some tasks, states are better at leading innovation than markets and companies.

The best known contemporary advocate of state led innovation is Mariana Mazzucato, the University College London professor and author of *The Entrepreneurial State* who argues that states have always been leaders of innovation. Innovation in a variety of forms would be much more difficult Mazzucato argues were it not for the state's role as an investor, regulator and provider of services. Her work stands in a long tradition which has more resonance outside the Anglo-Saxon world that has been so influenced by free market thinking. As economic activity, power and influence shift south and east in the world, so will thinking about innovation. The state will be a significant player.

In the 1960s – 1980s, the National Innovation Systems school of thinking, which started in the US and Europe, particularly influenced by Scandinavian models of innovation, argued that innovation emerged not just from companies but from entire systems that linked investment, skills, companies and markets. Government had an important role in orchestrating these systems. Economic

geographers have long highlighted the role of regional and city governments in creating the conditions for clusters to develop, providing the “collective competition goods” of infrastructure, education and culture which helps to create them. The success of Asian Tigers – South Korean, Singapore, Taiwan – is in part due to close collaboration between business and developmental states, often in the form of highly entrepreneurial and mission driven innovation agencies, a recipe that China has learned from. The success of small states as leading innovators – Israel and Finland stand out – stems from dense public, private partnerships to explore opportunities for innovation. More recently rich economies exploring how to escape their dependency on oil and natural resources – Saudi Arabia and Norway - have turned to the state, in the form of Sovereign Wealth and Development Funds to chart their way into the future, to make investments on behalf of the nation.

The state is a vital actor in innovation.

States are important to mobilise resources at scale especially in times of crisis such as war or more recently financial crisis. States are important to innovation in public goods where private market solutions often lead to under investment and so not work so well. Government has often provided initial funding for basic scientific research which later leads to commercial exploitation. The development of antibiotics during WWII is a good example of all three of these roles of the state as innovator in action.

States are capable of taking on innovation projects - Moonshots are the most often quoted example – which are too large, too risky and offer uncertain returns which put off private investors. Statists argue government’s role as an entrepreneurial risk taker is becoming more important as large companies sit on swelling balance sheets, unwilling or unable to invest them in the risky new systems and products of the future. If corporations are so cautious about investment, then the state in some form may have to step in to unlock corporate investment, especially in the infrastructure needed to develop new industries and markets.

Capitalism is stalled not because the state is over-regulating nor because trade unions are too strong but because ample supplies of capital are not being used creatively to set in train the next long boom of investment, growth and employment. Capitalists are doing what is rational in the short term but not what makes most sense for the long-term prosperity of the economy as a whole.

To kick-start a new wave of investment, the statisticians argue, state investment funds should be directing investment to create public value and benefits in terms of future employment. The systems we need to meet the SDGs it seems will be made by states encouraging firms to making big bets on the future, much as they have in the past.

### **Fragile State Innovation**

The SDGs will not be achieved unless there is significant innovation in fragile states to make them far more effective in providing a basic, decent standard of living for their citizens.

For most of the 20<sup>th</sup> century policy-makers and diplomats worried about states becoming too ambitious and powerful. Now they worry that the international order will be disrupted by states that are too weak and fragile. In the places that are furthest from reaching the SDGs the main problem is state fragility rather than state power.

The OECD estimates that about 1.5bn people live in states that suffer recurring, often violent crises. These states are home to perhaps a third of the world's poorest people and attract more than 30% of development assistance. Despite their relatively small size and seemingly peripheral position, many of these states are regarded as potent sources of disorder in an increasingly interconnected world, not least because the chaos that reigns in their nether regions can provide a welcome home for terrorist groups.

Fragile states, by definition, are places where public services of any kind, whether funded by national government or international donors, struggle to gain a foothold. Traditional recipes, used in more stable developing countries, are unlikely to work. Despite the international community's focus, the OECD concluded recently that little progress has been made in fragile states: "Most aid actors are neither set up to meet the challenges of fragile situations nor systematically able to translate commitments into action." As the Overseas Development Institute put it in a review of experience to date: the development industry needs a step change in its approach to have any significant impact on the "bottom billion" many of whom live in fragile states.

Fragile states have governments that are unable or unwilling to meet the most basic needs of their populations – for security, law, justice, water, energy, health and education. Social innovation to meet those needs more effectively with the scarce resources available should be central to the business and development agenda. Traditional development solutions are not working; business should play a role in creating more innovative solutions for fragile states.

## **Conclusions**

We are not lacking in opportunities and sources of innovation to provide solutions to our need. Businesses large and small, social and commercial, high-tech and no tech, can choose which path to follow to make their contribution to this effort. Some might see the brightest prospects in funding exponential technologies. Others may see the best route through creating frugal low cost solutions using existing technologies for consumers at the base of the pyramid. Others may recognise that achieving the SDGs will depend on public – private partnerships to create new platforms for growth, not least in the most fragile states of the developing world.

Nor are these five approaches exclusive. Indeed what is most likely is that they will be mixed together to create a wide range of hybrid ways to innovation.

Exponential innovations, especially artificial intelligence, will feed smart solutions. Frugal innovators will benefit from exponential technologies like atomically precise manufacturing which could allow a flowering of localised manufacturing systems using readily available materials. Humanists will use exponential technologies, like growing human tissue to improve health care and extend life. Statist innovators will remain vital to exponential innovation, for example in funding much of the basic research that will go into their breakthroughs, from nano machines to aeroponic agriculture. Frugal innovators will use smart technologies to create intelligent and adaptive systems. Frugal innovation plays a vital role in developing economies, for example powering the rise of low cost private education and has been recognised as a part of state innovation policy in India and China. Frugal innovation is also often human and local in scale.

The range of possible combinations of these approaches to innovation will grow. That will reward those companies able to work in more than one field at the same time. The ability to form partnerships with other companies large and small, with social innovators and community activists, with philanthropic funders and state agencies will be critical. Innovating new systems will require broad alliances and partnerships, new ways to share risks and reward.

Business should lead the collaborative innovation programmes needed to tackle systemic challenges inherent in the SDGs. This will mean building innovation alliances in a variety of forms.

Leading businesses could work with government innovation agencies and philanthropic funds to create SDG System Change Labs around the world to bring together the multiple stakeholders who will need to collaborate in promoting system change in water, energy, food, education and health. These system change labs should create shared maps of opportunities for complementary innovation.

Business should create a large SDG Challenge Prize Fund, to create a global focus for entrepreneurs and innovators coming up with potential exponential solutions to SDG challenges.

Businesses should support frugal innovation through a global platform based on shared IP and resources, to spread the skills and techniques of frugal entrepreneurship. Business can provide much needed scale, skills, credibility and resources to these frugal efforts. Large companies should join with governments and philanthropists to create a string of SDG Frugal Innovation labs across the developing world where large companies and grass roots innovators can work together in a collaborative environment.

Business should lead efforts to develop education systems that promote the entrepreneurial skills of collaborative problem solving. This involves not just spreading knowledge but skills of risk taking, agency, resilience and collaboration. Business should be a leading player, along with international organisations such as the OECD and Unicef, in supporting new forms of education which will equip young people to understand and tackle the complex problems inherent in achieving the SDGs.

Governments should use public money to activate dormant cash on corporate balance sheets to invest in “public-production systems” for creating public goods such as water, health, education and a clean environment. Inventive public subsidy could catalyse large amounts of private investment in these new infrastructures and systems, activating the very large sums of cash sitting on corporate balance sheets.