

HiAlba-IDEA

**At this stage HiAlba-IDEA is a virtual think tank – HI (Highlands & Islands)
Alba (Scotland) IDEA (think tank) – with plans to operate as the first
HI think tank from a base in Portree on the Isle of Skye.**

**Folk of independent mind with the interdependent purpose of
maximising Scotland's well-being by bravely innovating:
pursuing with passion, enacting with compassion.**

Maximising Scotland's Well-Being by Bravely Innovating

The productivity puzzle and how to solve it needs new thinking.

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Maximising Well-Being

While Adam Smith provided the foundation of well-being analysis in economics per se, he did so by first contributing with supremely enlightened distinction to the intellectual foundation of moral philosophy, thereby ensuring for all time the need to consider well-being as a cross-fertilisation between different fields of thought and their ensuing conceptions to maximise the well-being of individuals, nations and the environment.

Time for Bravely Innovating?

"It is fascinating to speculate on what might have been, had the industrial revolution been based on electric power instead of steam. Possibly the great centres of population would have been found in the north rather than the Glasgow-Edinburgh-Dundee belt."

A.K. Cairncross

From.....

The Crofting Problem, Adam Collier, Foreword & Edited by A.K. Cairncross
Glasgow University Economic and Social Study
Publisher University Press, 1953

From Speculation to Imagination to Reality

"Imagination creates reality"

Richard Wagner

"Imagination is more important than knowledge.

For knowledge is limited to all we now know and understand,
while imagination embraces the entire world,
and all there ever will be to know and understand."

Albert Einstein

Foreword – Bravely Innovating

“Imagination creates reality” says Wagner and Skye cousins Ronald MacDonald and Donald MacRae when they ask Scots to imagine Scotland at the fore of major advancements to improve the human condition at home and abroad.

Imagine Scotland enabling an energy independent Europe by collaborating with energy majors to build and operate an electricity Supergrid powered by renewable energy from offshore windfarms that generate power 24x7 with zero transmission losses.

Imagine Scotland as a financial and technology enabling centre for the establishment of renewable energy Supergrids worldwide.

Imagine Scotland as a centre for decentralisation by demonstrating how eco-industrialisation, distributed ledger technologies (such as blockchain) and advances in artificial intelligence can attract jobs to regional, rural and remote areas, empowered by rapidly decreasing costs of energy and by innovation in using local natural resources.

Imagine Scotland as a global leader in vegan food production, largely based on the use of local natural resources, including Japanese-scale seaweed harvesting in tandem with the operation of offshore windfarms.

Imagine Scotland once again as a great shipbuilder, this time to facilitate two major advances:

- (a) to rid the world’s seas and oceans of plastic waste through the application of onboard machinery to convert plastics to biodiesel to power the ships 24x7 and pollution free;
- (b) to harvest seaweed from offshore windfarms;

noting that the [world’s first sea-going renewables-powered hydrogen ferry](#) is being built by the shipbuilding company owned by businessman and entrepreneur Jim McColl.

Imagine Scotland at the fore of efforts to ensure that the current rapid development of artificial intelligence is matched with ethically-driven advancements seeking to guarantee beneficial outcomes for humanity, notably building the social capital of all nations and peoples focussed on alleviating global poverty and enhancing the quality of life and resilience of all peoples.

Imagine Scotland sharing in the returns from the foregoing to establish and grow a Sovereign Wealth Fund to build the social capital of the nation and Scots in ways that are replicable for other nations and their peoples.

MacDonald and MacRae propose what they refer to as a *Greenprint* to create the reality of the renewable energy Supergrid for Europe.

Greenprint for European Supergrid

Step 1: Noting that ammonia is an effective, well-established way of transporting hydrogen, accelerate the application of a new [Australian technology](#) to reduce markedly the cost of extracting hydrogen from ammonia.

Step 2: Accelerate the [existing use of renewable energy to produce ammonia](#) that is much cheaper than existing hydrocarbon-based polluting processes.

Step 3: Accelerate the development of processes to produce ammonia directly from energy, air and water: [Solid-State-Ammonia-Synthesis](#) and a [customised fuel-cell process](#). Oxygen bi-product would be a major opportunity in its own right.

Step 4: Accelerate existing initiatives to [lower markedly the cost of producing blades and turbines](#) and offshore windmill towers and anchoring to accelerate, in turn, the existing uptake of offshore windfarms, noting that

Scotland features with Norway in establishing the [world’s first offshore wind farm](#).

Step 5: Partner with [Norway](#) and [Australia](#) in assessing the feasibility of transporting ammonia as a carrier of hydrogen for existing uses in all forms of electric-based transportation (including cars, buses, trucks, trains, ships and planes) and electricity generation for food production, human habitation and industrialisation.

Step 6: Accelerate existing research efforts to use [graphene as a super-conductor](#) for near zero-energy losses in the transmission of electricity.

Step 7: Accelerate [Australian company's](#) R&D and early stage commercialisation of a process for low-cost, carbon-neutral extraction of graphite and hydrogen from natural gas, possibly facilitating an acceptable way of utilising Scotland's onshore natural gas reserves. Evaluate ways to use by-product hydrogen for electricity to achieve carbon-negative production of graphite for electric vehicle battery production and to use in local, national and international electricity grids.

Step 8: Accelerate the development of technologies to produce graphene from graphite and its effective use as a super-conductor, especially in the [transmission of electricity](#).

Step 9: Evaluate the feasibility of using old oil & gas rigs as platforms located (throughout a vast array of windfarms located in the continental-shelf Atlantic and North Sea) to produce ammonia and store in large undersea tanks for conversion to electricity in periods of low wind, thereby delivering a continuous, non-intermittent supply of electricity.

Step 10: Produce a blueprint to integrate the foregoing into a comprehensive [technology roadmap](#) to establish offshore wind farms in the Atlantic and North Sea that

will provide levels of 24x7 zero-loss transmission of electricity on a scale that will deliver energy independence for Europe through a European Supergrid, as envisaged by wind-energy entrepreneur Eddie O'Connor in "[An engineering vision for a New Europe](#)".

Step 11: Prepare a [financial roadmap](#) that demonstrates how to supplement long-term reducing returns to partners/investors from the ever-decreasing cost of producing renewable energy by returns from the industrial, municipal and other major users of the Supergrid (e.g. as a distributed-ledger process to authenticate agreements: (a) on the ongoing quantum of increases in returns commensurate with the reductions in energy costs; and (b) on the allocations of shares from these returns and to facilitate the disbursements of these allocations).

Step 12: Use Supergrid technology and financial roadmaps as the basis of forging a grand collaboration with energy majors to invest in and implement the infrastructure to realise the renewable energy production for the European Supergrid as a forerunner to electricity grids worldwide.

Step 13: Evaluate the feasibility of Supergrids for other regions of the world, noting that in Africa not only could low-cost, non-polluting energy be delivered but also ammonia for fertilisers that African farming desperately needs.

For MacDonald and MacRae, an insight guiding the "art of the possible" in realising the reality of a Sovereign Wealth Fund is attributed to businessman, entrepreneur and philanthropist Sir Tom Hunter reminding us that Andrew Carnegie considered...

"a man who dies rich, dies disgraced".

For those that think this is beyond Scots and Scotland, checkout the source of the popularised "Beam me up Scotty" accolade reflecting Scottish "game changing" contributions to global enlightenment and the advancement of science, technology and engineering that includes:

*moral philosophy – classical economics – modern finance – UK central banking
steam engines – thermodynamics (latent heat) – temperature measurement
logarithms – computation – electromagnetism – [electric vehicles](#) – bicycles – sealed roads
tyres – water-proof fabrics – telephony – television – radar – antibiotics (penicillin)
stem cell research – gravitational wave detection – "boson" particle physics
wave & tidal energy – [kite power](#) – [LiFi-IoT](#) – [emerging energy storage technology](#).*

MacDonald and MacRae are also influenced by Einstein's ruminations on imagination: "Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand."

They conclude that our shared imaginations as a people at home and abroad will rebirth us as a nation inspiring global enlightenment.

Executive Summary

This is an Overview of a program of proposed initiatives of the virtual think tank HIAIba-IDEA – HI (Highlands & Islands) Alba (Scotland) IDEA (think tank) – with plans by its co-founders Ronald MacDonald and Donald MacRae to operate from a base in Portree on the Isle of Skye. We envisage the creation of considerable benchmarkable gains in both productivity and economic growth by: (a) accelerating Scotland's impressive decarbonisation of its economy; (b) decarbonising to maximise economic, social and environmental gains from decentralisation; (c) being at the forefront of information technology of digitalisation to decarbonise to decentralise.

Decarbonise: Scotland could maximise the benefits of decarbonising its economy by generating a flow of renewable energy that not only matches the UK-based flow of oil & gas from the North Sea but exceeds it to the extent that it becomes one of the largest global energy exporters in the world. We envisaged that it would do so through the low-cost extraction of hydrogen from renewably generated ammonia used as a storage medium and carrier of hydrogen. And in so doing blaze trails in supporting the global community to adapt decisively to containing the adverse impacts of climate change at globally significant levels.

Decarbonise to Decentralise: We reason that as hydrogen becomes increasingly central to national economies, remote, rural and regional areas of Scotland are best placed to generate and export on a massive scale. As a consequence, not only will these areas then be provided with ever improving levels of educational and health services, we outline in this paper that the local availability of abundant cheap renewable energy can also lead to major exports of education and health services. By the same token we outline wide ranging opportunities for remote, rural and regional Scotland to increase massively the manufactures of food products, advanced technology products and IT-based services to the scale of global corporate-scale players. We envisage that such decentralisation will also advantage Scottish cities in major ways by: (a) boosting levels of supporting manufacturing of technologically advanced products and services that could be leveraged into major export outcomes; (b) leading to renewable energy steelmaking and graphite-to-graphene products; (c) building autonomous, real-time self-fuelled ships for (i) vast increases in ammonia transportation, (ii) cleaning up plastic infestations of the oceans and seas running on biofuels produced real-time from the plastics collected, (iii) roll on roll off shipping to transport autonomous refuse collection vehicles (RCVs) running on biofuels produced real-time from the plastics and bio-wastes collected; and (d) ironically making it possible for Glasgow and Edinburgh to evolve as a conurbation with productivity levels matching that of Greater London but so doing without incurring the income disparities prevailing in England.

Digitalisation to Decarbonise to Decentralise: Many illustrations are provided of the roles of digitalisation in delivering the foregoing, notably harnessing AI-governed-machine-learning based on "desiloised" access to myriad "Big Data" holdings through secure Distributed Ledger Technology (DLT) networks.

Beyond the "3D" era: We make a case for DLT-based networking of Scottish science & technology based entrepreneurial startups with startups worldwide, led by those of the Scottish diaspora and interaction with the California based Singularity University's startup initiative and their "exponential technology" Summits.

Benchmarking Productivity: We make a case for benchmarking productivity improvements for three of the four EU regions for Scotland (namely North-East, South-West and the Highlands & Islands) to the much higher levels that prevail in Norway and, as noted above, a several hundred percentage improvement in the Glasgow-Edinburgh conurbation, spanning the fourth region, to match or exceed the level of Greater London.

Centrality of Social Capital: We perceive the need for innovation in building social capital given its role as the preeminent driving force in achieving and mobilising the quality of human capital to maximise well-being. We consider social capital resources such as trust, cultural norms, and networks of association.

Policy Relevance: Recent technological advances now proffer many opportunities for Scotland to maximise the benefits from its impressive strengths in renewable energy by further decentralising governance to engage comprehensively with local communities-of-interest, in harnessing two game changing opportunities: (1) the production of renewable hydrogen for massive scale exports; and (2) distributed ledger technologies for central governments to lead by allocating responsibilities to decentralised entities in achieving these benefits maximally, confidently and securely. We note that Norway and Switzerland, two of the most successful tech-savvy economies in Europe, are not only socially progressive but also operate highly decentralised systems of governance while eschewing the overarching strictures entailed by membership of the European Union.

This Overview seeks to begin an inclusive conversation to examine the validity of the foregoing.

1. Introduction

This is an Overview of a series of papers that will report on proposed investigations to identify and evaluate latent³ opportunities – existing, emerging, expecting – that if realised could contribute to maximising the well-being of not only Scotland's citizens but the natural environment and resources which sustains them. We

³ Latent in the sense of realising undeveloped opportunities of unreleased potential, analogous to Joseph Black's release of "hidden" thermal energy leading to advances in thermodynamics and James Watt's steam engine technology both at the University of Glasgow along with their firm friend Adam Smith, all fellow members of the Scottish Enlightenment.

envisage such realisation depending on meshing “bravely innovating” processes of governments, enterprises and communities-of-interest to enhance Scottish strengths, particularly in export endeavour, in existing and emerging sectors and to shape the environment for “back-to-the-future” expectations of resurgent enlightenment.

We perceive the need for innovation in building social capital given its role as the preeminent driving force in achieving and mobilising the quality of human capital⁴ to maximise well-being, broadly defined. We consider social capital resources such as **trust**, **cultural norms**, and **networks of association**.

The post financial crisis is one in which the productivity of both the UK and Scotland has been seriously challenged and there are a number of well-known explanations for this, such as the long tail of underperforming firms and a poor management culture and ethos pervading many companies. Rather than revisiting these themes here, we focus on the key role of innovation as the driver of productivity. We concur with the view espoused in the [The Four Must Haves for Innovation](#) that “for innovation to fulfil its potential, there are four elements that must be aligned: meshing **purpose**, **leadership**, **strategy** and **culture** is the way to new value creation.”

In terms of **Purpose**, the case will be made in the papers for Scotland to take a “bravely innovative” lead role in “public purpose”, as exemplified by the [Institute for Innovation and Public Purpose](#): “rethinking how public value is created, nurtured and evaluated”.

We envisage **Leadership** as every individual’s responsibility – we perceive that Scotland will enlighten once more and do so in highly productive ways if communities, innovators and enablers⁵ populate each other’s minds on how to realise the opportunities arising from decarbonising economies, decentralising to optimise well-being in urban, rural and remote habitats, and digitalisation supporting such realisations; decarbonising mainly through a “game changing” opportunity for Scotland by generating renewable energy to produce (a) ammonia-hydrogen for exporting on a massive scale and (b) highly innovative products and create enabling services using local and regional resources (including human and social capital) for local and national consumption and contributing to a massive scale export effort of services as well as products.

The right **Strategy** is required to shape the environment in a favourable way. Specifically, we perceive ways of delivering spectacular productivity gains to grow the economic pie and by sharing it more equitably accelerate that growth.

In our proposal **Culture** is the force multiplier – from the role of modern crofting as a catalyst to “awakening the giant” of the Highlands and Islands potential to “populated-mind” teams focussed on realising latent global-scale, renewable energy distribution and consequent opportunities in manufacturing and services throughout Scotland, primarily supported by harnessing massive flows of FDI to build-own-operate the enabling renewable energy infrastructure.

A critical element in our work is that we emphasise **well-being creation** as the ultimate goal of kick-starting productivity and growth, rather than a sole focus on wealth creation. This emphasis is crucially important since it emphasises relationships, in the form of social capital, and mental and physical health, argued by some economists as key components of human capital together with educational attainment and financial independence. And for an economist’s take on happiness, we have this insight from Adam Smith: “*What can be added to the happiness of a man who is in health, out of debt, and has a clear conscience?*”: perhaps viewing “health” as physical health, mental health related to a “clear conscience” and financial independence equating to “out of debt”. So, we think of well-being in a holistic way rather than the narrower focus that has been used in recent policy debates. This is also the tack now being taken by the Boston Consulting Group (BCG) following its study [Striking a Balance Between Well-Being and Growth](#) in which they find that “there is no need to choose between well-being and growth. BCG’s 2018 Sustainable Economic Development Assessment reveals that countries can make the overall welfare of citizens the top priority while promoting sustainable and robust economic growth”.

It follows from such an emphasis that although a good proportion of the slow productivity growth that has been on the radar in both the UK and Scotland of late is not just attributable to the depreciation and quality of

⁴ In 2017, the UK’s real full human capital stock was £20.4 trillion, equivalent to just over 10 times the size of UK GDP.

⁵ Local, regional and national forms of governance and corporates awake to the opportunities offered by renewable energy futures.

physical and human capital but also the depreciation of social capital, a much under researched source in the recent literature. Social capital has been linked to a number of positive outcomes, including, for example, mental health but few studies have examined the role of [social capital and mental health and well-being](#) concurrently. In this respect, depression is ranked by WHO as the single largest contributor to global disability (7.5% of all years lived with disability in 2015); anxiety disorders are ranked 6th (3.4%). Depression is also the major contributor to suicide deaths, which number close to 800 000 per year. The influential book [Lost Connections - uncovering the real causes of depressions - and the unexpected solutions](#) (January 2018) seeks redressment. Also relevant is the thinking underpinning the 2001 OECD report [The Well-being of Nations—the role of human and social capital](#) which in considering the relationship between human well-being, economic well-being and GDP concludes that economic well-being is broader than measures such as GDP “...and political, institutional and legal arrangements are extremely important complements to human and social capital.”

The key strategic element of our proposal, and made in the proposed papers, is that the Highlands and Islands of Scotland (an area the size of Wales and vitally important to the Scottish economy), and more widely the whole of Scotland, should take a “bravely innovative” approach to conceiving and delivering innovation and public purpose in capturing the opportunities of the **3D era** of Decarbonisation, Decentralisation and Digitalisation. In particular, we envisage the **Decarbonisation** of electrification and transportation (through a “game changing” use of renewable energy to produce ammonia as a store and carrier of hydrogen), driven by very rapid reductions in the cost of renewable energy and a dramatic breakthrough in reducing the cost of producing hydrogen from ammonia which we believe could have revolutionary implications for the Scottish economy.

Decarbonisation should in turn be used to create **Decentralisation** by rapidly decreasing costs of generating and using off-the-grid renewable energy at the local level for residential living and sustainable production of export goods from local and regional natural resources, supported by blockchain and Decentralised Ledger Technologies (DLTs) that facilitate participating communities to maximise their returns from inputs to the national grid. And a future where drones support the delivery of medicines and defibrillators by operating as full-sized auto-fly ambulances with wearable MRI/CT scanning devices and 5G telemedicine is commonplace.

We argue for the adoption of **Digitalisation** into every relevant facet of human behaviour and endeavour through advances in inter alia: autonomous electrical vehicles and the security and controllability of transportation systems; AI and machine learning (e.g. delivering medical diagnosis and robotised treatments globally); additive and increasingly robotised manufacturing.

2. The 3D era

Permeating our thinking as well as [social capital building imperatives](#) and *The Four Haves of Innovation* is a growing awareness of what we refer to as the emerging 3D era and the enhanced expectations that it engenders. Not 3D in a dimensional sense, such as the potential of 3D printing, but 3D characterising the major societal change processes of Decarbonisation, Decentralisation, Digitalisation...

As noted above, the key objective of our proposal is that the Highlands and Islands of Scotland, and indeed more widely all of Scotland, should take a “bravely innovative” approach to conceiving and delivering innovation and public purpose⁶ in capturing the opportunities afforded by the **3D era**. Opportunities which are accelerating the processes of:

- **Decarbonisation** of electrification and transportation (through a “game changing” use of renewable energy to produce ammonia as a store and carrier of hydrogen), driven by very rapid reductions in the cost of renewable energy and a dramatic breakthrough in reducing the cost of producing hydrogen from ammonia which we believe could have revolutionary implications for the Scottish economy.
- **Decentralisation** with its attendant manifold societal benefits that could be realised by rapidly decreasing costs of generating and using off-the-grid renewable energy at the local level for residential living and sustainable production of export goods from local and regional natural resources, supported by [blockchain](#) and Decentralised Ledger Technologies (DLTs) that facilitate participating communities to maximise their returns from inputs to the national grid. And a future where drones support the delivery of medicines and

⁶ As exemplified by the [Institute for Innovation and Public Purpose](#): rethinking how public value is created, nurtured and evaluated.

[defibrillators](#) by operating as [full-sized drone ambulances](#) with wearable MRI/CT scanning devices⁷ and [5G telemedicine](#) is commonplace.

- **Digitalisation**⁸ expanding applications of information and communications technologies into every relevant facet of human behaviour and endeavour through advances in:
 - a) Autonomous electrical vehicles and the security and controllability of transportation systems.
 - b) Artificial Intelligence (AI)⁹ algorithms underpinning Big Data analyses leading to machine learning (ML)¹⁰ outcomes (e.g. delivering medical diagnosis and robotised treatments globally).
 - c) Additive and increasingly robotised manufacturing.
 - d) Security and controllability of ubiquitous Internet-of-Things (IoT) devices.
 - e) DLTs¹¹, including variants of blockchain technology eventually delivering stable (i.e., declining bubble latency) advances in crypto currencies underpinning sustainable financial systems (i.e., less characterised by Central Bank money creation and the global dictates of the “[exorbitantly privileged](#)” US dollar), and the formulation and management of all manner of contractual agreements.
 - f) DLT acceleration of advances in health services and genomics (and collaboration with the Digital Health Institute of Scotland in training DLT coders and delivering various health training initiatives initially from Skye and subsequently HI wide - see section 7.

In embracing **decarbonisation**, Scotland is clearly already a world leader in the transition to renewable energy-based electrification. This has afforded vanguard opportunities in the development and installation of innovative renewable energy technologies. And with this the enhancement of the prospects for increasing the productivity of the manufacturing and transportation systems they enable. Notable advancements in Scotland include siting of the [world's first floating wind farm](#). Add to this the world's first commercial applications in harnessing [wave and tidal energy](#), [kite-generated electricity](#), and a recent [geothermal venture for district heating](#). Further add, various forays into enhancing the prospects for the contributions of hydrogen to fuelling pollution-free and increasingly productive transportation systems and of course the large number of wind farms that are now sighted all over the Scottish landscape, some of which are controversial.

Accelerating the processes of decarbonisation is a willingness to enact systems of taxation that produce this outcome. A useful assessment starting point is the 2015 OECD report [Aligning Policies for the Transition to a Low-Carbon Economy](#) and its consideration of taxation reforms looking at energy and beyond by assessing: (a) the taxing issue of low-carbon economies; (b) how energy subsidies and taxes undermine climate change action; (c) beyond energy taxes - tax signals hindering low-carbon choices; (d) where next for tax revenues and budgets in the context of lower fossil energy use? We make the case that worldwide efforts seeking to boost national productivity through **decentralisation** would be ideally suited to Scotland's noble crofting heritage and culture, holding the potential to catalyse the creation of productive communities maximising well-being creation in contradistinction to a sole focus on maximising wealth creation. We see this development as crucial, for example, in stopping the process of splitting up crofts for development that has become so prevalent in parts of the Highlands such as Skye. We will seek answers to whether this has the potential to reverse the breakdown of that culture through the drift to incomers buying the crofts for pepper corn prices, de-crofting and selling on the land as developments.

For many the era of crofting seems long past and this seems very evident to one of the authors based on Skye where de-crofting and the use of crofting land for effectively property speculation seems to have become the norm. Markedly increasing land values for new townships and in this case the adjoining crofting community(ies) could be internalised along line of this article from The Economist (Apr 2015), “[Why Henry George had a point: Ideal in theory, elusive in practice: the case making landowners pay for the benefits which location gives them.](#)” And more recently from The Economist (Aug 2018): [The time may be right for land-value taxes](#). No free loaders, no developers making a killing, scaling landowner tax from the lowest for crofters, then productive residents to virtually prohibitive land taxes for the absentee landowners/landlords/lairds. The Lincoln Institute's report, [Assessing the Theory and Practice of Land Value Taxation](#), provides real world

⁷ New technologies utilising light and sound to track tumours and measure neural activity may replace the CT and MRI scanners with a cheaper, more efficient and [wearable system](#)

⁸ Cf. [digitisation](#) to increase the efficiency of processes.

⁹ [Artificial Intelligence: opportunities and implications for the future of decision making](#), UK Government Office for Science, 2016.

¹⁰ Useful descriptions and applications of the increasingly sophisticated interplay between AI, ML and Big Data analysis are provided in the report [Computational Modelling: Technological Futures](#), UK Government Office for Science, 2018 and in overview by Muffy Calder et al, “[Computational modelling for decision-making: where, why, what, who and how](#)”, Royal Society Open Science, June 2018.

¹¹ [Distributed Ledger Technology: beyond block chain](#), UK Government Office for Science, Jan 2016 and the [Video](#).

experience on land value tax (LVT) implementations. The [Wikipedia article on LVT](#) states that that Adam Smith “first rigorously analyzed the effects of a land value tax, pointing out how it would not hurt economic activity, and how it would not raise land rents” and provides quotes on varying degrees of support of LVT from modern economists, including Alfred Marshall, Paul Samuelson, Milton Friedman, Michael Hudson, Paul Krugman and Joseph Stiglitz.

Also, of possible relevance would be an assessment of the small and medium size enterprises unique to Germany, and the backbone of its strong economy as reported in [“Prosperity through cooperation – Germany’s economic miracle – case studies](#): an investigation of their underlying concepts, characteristics, and how they thrive in competitive markets while being socially responsible”.

One of the oft heard criticisms of the way crofting has developed in the Highlands is that the breakdown of the traditional crofting communities amounts to a breakdown, or perhaps more correctly the depreciation, of social capital and the profound implications this can have not only for the culture but the broader economic environment. But we believe such depreciation has a wider resonance across modern day Scotland and indeed beyond.

The concept of [Social Capital](#) was first introduced by [L. J. Hanifan](#) in 1916 and described “as those tangible assets [that] count for most in the daily lives of people: namely goodwill, fellowship, sympathy and social intercourse among individuals and families who make up a social unit”. As Robert Putnam’s analysis of social capital in the USA demonstrates, in his best-selling book [Bowling Alone](#), the importance of understanding changes in social capital has important implications for a nations overall Well-being, including its productivity capacity and consequently economic growth. Putnam argues that although Americans have become wealthier in aggregate in the last century their sense of community has declined and depreciated. ‘Cities and traditional suburbs have given way to ‘edge cities’ and ‘exurbs’ – vast anonymous places where people sleep and work and do little else’ (see, for example, [OECD Insights: Human Capital – What is Social Capital?](#)). Putnam uses the example of bowling to argue that the decline of the community networks that once led Americans to bowl together represents a loss of social capital.

James Coleman in his article *Social Capital in the Creation of Human Capital* has argued that Social Capital is an important component of human capital and therefore a key determinant in the productivity/economic growth nexus. Francis Fukuyama in *The Social Virtues and the Creation of Prosperity* pushes this further by noting that the ability for people to associate and create social capital is a function of Trust which can be demonstrated to have measurable economic value. The decline of trust and sociability in many advanced countries has led to the breakdown of social capital in terms of the family and a wide range of intermediate structures. The concept of social capital and particularly its implications for inequality has been highlighted more recently (2012) by Charles Murray in his book [Coming Apart](#). Possible the most powerful insights into eradicating poverty are posed by economist Daron Acemoglu and political economist James Robinson in [Why Nations Fail](#) depends on whether the institutions of a state are “inclusive” or “extractive”, where the former accords its citizens a say in decision-making and the latter privilege the voice of the few allowing them to exploit and rule. Just as the threat of the authoritarian state oppresses so also does market fundamentalism exacerbate disparity and deprivation. To avoid the tyranny of both democratic politics is key to reinforcing the role of society in fostering the forms of civic engagement essential for participation and accountability in public and political life.

In sum, the key point here is that the social capital represented by related networks and understandings engenders trust thereby enabling people to work together and that inevitably has consequences for productivity and growth. One particular concern is that there is bound to be a further depreciation of social capital in Scotland as the kind of digitalisation processes referred to above develop. Accordingly, we reason it is crucially important in moving forward to recognise the role of social capital as part of the big picture to improve Scotland’s productivity.

It is noteworthy that in his writings on crofting in Scotland that James Hunter has articulated the need for what is effectively social capital in crofting communities as being more important for economic development than other more conventional methods. This view was clearly expressed in a recent publication¹² in which Hunter strongly supports the retention of an independent Highland and Island Enterprise and it is worth quoting from that piece here:

¹² J Hunter (2017), ‘The Board must have powers to act at its own hand’, in (Ed) I MacDonald, *On Scotland’s Conscience*.

[The commitment of HIE] ... to backing all sorts of undertakings that, on the face of things, have little to do with economic development as commonly understood: local history societies; heritage centres; theatres; the Fèisean movement which has brought about a flowering of interest in traditional music and song; Gaelic-medium playgroups; Scotland's Gaelic-medium college at Sabhal Mòr Ostaig in Skye; football clubs; sports and leisure facilities. Investments of this kind (and there have been a lot of them) were made not because HIE/HIE considered that enhancing the standing of, say, Gaelic or traditional music is good in itself – though it is. What has underpinned all such spending is a conviction that to do this sort of thing is simultaneously to boost self-belief and self-confidence in ways that eventually translate into increased business activity.'

In **digitalisation** the case is made throughout the proposed papers that AI and machine learning (ML) can extend the global reach of Scottish medical services (from cities and regional centres) and be a major player in the industrial scale development of attendant advances in enabling software. Also, as DLTs begin to underpin - (a) secure and increasingly productive peer to peer transactions, (b) secure financial transactions and (c) secure contractual needs - Scotland by embracing decarbonisation and decentralisation opportunities will naturally create and export attendant advances in DLTs software at an industrial scale of endeavour.

While there is an understandable step back from 'digital revolutions' among many, we reason that having missed out on the massive commercial (and not always admirable) gains made by the Internet giants, Scotland could be in the vanguard of the development of software enabling AI, ML and DLT applications on a commensurate scale by actively embracing the opportunities of the 3D era. But in doing so, we envisage that this generation of software development offers routes to being vastly more productive, secure and well-being enhancing than that arising from current social media offerings and the increasingly anticompetitive behaviour of online search and social networking services (transitioning from a nascent generosity of spirit in a "do no evil" reach to the blind-eye commercial expedient of a "see no evil" grasp¹³).

With major investors and foundation developers of Facebook withdrawing support and [growing](#) concerns about threats imposed by the [behaviour modification empires](#), Facebook and Google, there are increasing efforts to conceptualise the creation of [sustainable information ecosystems](#) free of ever more insidious incursions into human privacy driven by advertising technology and "big-data, deep-learning applications" that threaten the future of democracy. Beyond conceptualisation comes [BAT](#) offering a blockchain-based digital advertising technology cryptocurrency exchanges between publishers, advertisers and users where users control their peer-to-peer networking data and are paid for its uses in ways they deem appropriate. And [Hold](#) a smart-phone app seeking to reverse the growing productivity sapping trend in smart-phone addiction by providing rewards (cinema tickets, coffee, drinks, etc) for set periods of abstention. Also, the youth-inspired, despair reducing initiative, [Repereceived](#), that is "bringing together young people from around the world to explore a range of current issues. From politics, social issues, education and human rights to religion, the environment, economics and modern technology."

Of course, one of the key challenges in the digitalisation agenda is that it will undoubtedly lead to, perhaps spectacular, productivity gains but it may also lead to challenges of employability along the lines of the issues discussed at the [Scotland's Inclusive Growth Conference](#). Many recent assessments, including a recent Asian Development Bank report, reason that automation and other changes will ultimately lead to the creation of more jobs in the coming decades than are displaced through rising demand spurred by improved efficiency or productivity. Serial entrepreneur Nathan Myhrvold writing in Scientific America (April 2018) provides a well-reasoned anti-luddite perspective in his article: ["What the History of Math Can Teach Us about the Future of AI: Domsayers say it will put us all out of work, but experience suggests otherwise."](#) However, of greater concern is the type of jobs and the degree of financial security they will secure. While it's more than likely that the economic pie will grow larger with ever more to share around, how do we do this much more equitably than has occurred in the past 50 years?

Many assessments are coming to the fore concerning the provision of incentive-based basic incomes. Two recent Ted Talks traversing the issues ["How we'll earn money in the future without jobs."](#) and ["Poverty isn't a lack of character; it's a lack of cash."](#) exhibit advances in thinking since the Thatcher pronouncement, "Poverty is a personality defect." As [Ontario](#) gears up for a major basic income trial and [Finland](#) is already trialling, but

¹³ We envisage an avalanche of software development opportunities and Unicorn start-ups arising from benevolently countering: (a) persistent worldwide efforts of entities seeking to circumvent/hack security of elections; (b) adverse impacts on child and adult mental health of social media giants, notably FB, Tw and YT; (c) invasion of privacy of individuals; (d) adverse impacts of social media monopolies on entrepreneurship and innovation - i.e. buying up start-ups to snuff out competition or to Hoover up talent thereby stunting the growth of entrepreneurship and innovation in a great number of countries and indeed the world at large.

seemingly not seriously enough, there is a burgeoning conversation online – e.g., [The Top 10 Best Blogs on Universal Basic Income](#) (UBI) and the [Basic Income Earth Network](#) – “Overview of Current Basic Income Related Experiments” (October 2017), including an account of proposed Scottish initiatives based on the highly regarded British think tank report on the potential for a basic income in the UK, “[Creative Citizen, Creative State](#)”. Useful insights are peppered through the comments on The Economist article [Automation and anxiety - Will smarter machines cause mass unemployment?](#)

In contrast to the benefits proffered by proponents of the UBI is the more targeted Universal Job Guarantee, championed by an increasing number of prominent economists, notably [Stephanie Kelton](#) (with expertise in US Federal Reserve operations, fiscal policy, social security, international finance, and employment policy) who with colleagues has produced various reports that examine the economic effects of implementing a nationwide job creation program by applying [Modern Monetary Theory](#), a macroeconomic theory that describes the currency as a public monopoly and unemployment as the evidence that a currency monopolist is restricting the supply of the financial assets needed to pay taxes and satisfy savings desires; e.g. [“Public Service Employment: A Path to Full Employment”](#) in April 2018.

Recent research on social mobility by Raj Chetty¹⁴ is analysing Big Data sets held by social security agencies to broaden the scope of national assessments to local investigations of what is already markedly increasing the prospects for children to overcome chronic intergenerational poverty. It would seem that DLT offers opportunities to accelerate the realisation of these benefits by fostering collaboration between efforts to extend the range of such investigations to local areas worldwide.

In short, we perceive that Scotland, by dealing effectively with the challenges of employability, will enlighten once more and do so in a highly productive way if communities, innovators and enablers populate each other’s minds to the opportunities of the 3D era, increasingly using AI, machine learning and DLT to facilitate outcomes. By enablers we mean local, regional and national forms of governance and corporates awake to the opportunities offered by renewable energy futures.

3. Beyond 3D – Profiling and Networking Startups

But why limit our aspirations to 3D. Why not add to the ‘D list’ further dimensions? Specifically, **D** for **Disruption** caused by rapid advances in innovation and technology? Mainly because the accelerating pace of innovation and technology change permeates all facets of decarbonising economies, decentralising populations, and digitalising societies and more. This is apparent in the papers the authors are preparing on ways in which the Highlands and Islands can maximise their own well-being while massively and sustainably boosting the export effort of Scotland.

And what about a fifth **D** for **Diaspora**? While Scotland’s diaspora has always stood ready to contribute to the advancement of Scotland in all spheres of endeavour, magnifying these contributions in the 3D era could abound, as encapsulated by this testimonial on the potential of [GlobalScot](#): “The GlobalScot network is undoubtedly one of Scotland’s biggest assets. Entrepreneurs and businesses need to exploit this resource to the fullest and work with GlobalScots to realize their full potential.” Consequently, the papers we propose preparing will consider prospective diasporic contributions systematically, notably in facilitating FDI.

These Ds pertain to what we can do now. In talking about exponential technology and its accelerating impacts on all aspects of the level of living for the next 20 years and beyond, Peter Diamandis, Cofounder with Ray Kurzweil of Singularity University, proffers a “6D’s” framework which he equates to “a lens through which I contextualise all technological change and opportunities”:

- **Digitized:** Turning every product or service into “1’s and 0’s.”
- **Deceptive:** The doubling of small numbers is deceptive. Start doubling 0.1 to 0.2... 0.4... 0.8... and at this phase, it all looks like “zero.”
- **Disruptive:** After we reach “1”, just 30 doublings later, we’re at 1 billion.

¹⁴ See the video: [using data to understand the causes of inequality and identify potential solutions](#). Also relevant is Chetty’s research on “[Moral Hazard versus Liquidity and Optimal Unemployment Insurance](#)”

- **Dematerialized:** Exponential technology turns tangible “things” into digital apps. I no longer carry around GPS equipment -- it’s an app on my phone.
- **Demonetized:** the cost of duplicating and sending an app is essentially zero.
- **Democratized:** Once products and services are digital, they go global and can become ubiquitous.

“A primary goal of Singularity University (SU) is to foster the rise of 1 million exponential entrepreneurs who use the 6 D's as a technological road map to predict where technologies are going and when to capitalize on the opportunities and who need to have identified a Massive Transformative Purpose, built a friendly relationship with failure, and have a sound understanding of exponential trends.” This is expanded on at [The 6Ds of Exponential Organizations](#).

“SU is a global community that uses exponential technologies to tackle the world's biggest challenges. It operates as a benefit corporation headquartered at NASA’s research campus in Silicon Valley, providing educational programs, innovative partnerships and a startup accelerator to help individuals, businesses, institutions, investors, NGOs and governments understand cutting-edge technologies, and how to utilize these technologies to positively impact billions of people.”

SU defines exponential technologies as those which are rapidly accelerating and shaping major industries and all aspects of our lives. Since 2016 they have convened a US-based annual Global Summit to dimensionalise exponential trends and technologies.

The Global Summit 2018, commenced on 20 August, and provided a stage for leading entrepreneurs and technology thinkers to expound in video form on several exponential trends including:

- Peter Diamandis - [The Future Is Faster Than You Think](#)
- Ramez Naam - [Foundation In Exponentials: Energy](#)
- AminToufani - [Exponential Transportation](#)
- Neil Jacobstein - [Foundation In Exponentials - AI](#)
- Suzanne Gildert - [Foundation In Exponentials: Robotics](#)
- Nathana Sharma - [Foundation In Exponentials: Crypto](#)

And despite pervading pessimism concerning the future of work by many in the face of such exponential trends, just absorb the alternate, optimistic near-term view by:

- John Hagel - [A Future of More Human Work](#) - Too often, the “future of work” conversation is framed as “win-lose” with companies and workers pitted against each other. In this session, we will explore some real examples of where the routine work of frontline workers has been redefined to be more fluid and creative, and what approaches others might take based on these experiences
- Edie Weiner - [Future of Work](#) | SU Australia Summit 2018 - Few would doubt the plethora of near future job opportunities by viewing and listening to Weiner’s fascinating account of existing and emerging forms of work illustrated with wide ranging examples of existing job titles that few have heard off, so far...

And even more encouraging, tune into the long-term view by:

- Vivienne Ming | [Future of Human Potential](#) - Exponential technologies have the capability to enhance and accelerate our abilities, helping us to reach our full potential as human beings by combining neuroscience and artificial intelligence complementing a growing understanding of the human brain to increase dramatically our ability to learn and to achieve.

SU has co-convened international summits in Australia, Czech Republic, Chile, Brazil, Germany and Thailand from February to June 2018 with forthcoming summits to be held in Italy, Portugal, South Africa, Sweden, Mexico, Greece, Colombia and Peru from October to December 2018.

The [SU Global Startup Program](#) and [SU Ventures](#) helps future-focused entrepreneurs transform radical ideas into tangible impact on a global scale. It’s a structured, immersive program offering startup-focused

educational resources and world-class mentorship from SU's faculty, staff, and industry experts—in a safe, nurturing environment. The program aims to scale startups into global businesses. "We want to inspire you to solve the world's biggest challenges and impact the lives of a billion people. Everything we do is built on top of three key pillars that are engineered to ensure your business thrives. We provide access to:

- Capital from angels, VCs, foundations, contracts, grants, and other sources to help your company grow
- Customers from pilots with our F1000 partners and field deployments with development organizations
- Connections to our global network of experts, esteemed faculty, and industry leaders

Most importantly, we understand long-term sustainability is key to the success of your startup. As a result, we take a long-term approach because we know you have big problems you're trying to solve."

Another contribution to profiling startups was initiated four years ago by LinkedIn when they started publishing annual lists of so-called Top Startups for the UK, USA, Germany, France, Italy, Australia, and Canada. They do this by profiling companies reaching "escape velocity" as ascertained from billions of interactions generated by LinkedIn's 575 million members based on four factors: employee growth; jobseeker interest; the level of professional engagement with the company and its employees; and how well the startup pulled talent from the [LinkedIn Top Companies list](#). That is, which startups commanded the attention and working hours of top talent? To be eligible for Top Startups, companies must be seven years old or younger, have at least 50 employees, be privately held and headquartered in reviewed countries. In 2018 they published lists of their most sought after 25 startups in the UK, 50 in the USA, 10 in Germany, 10 in France, 25 in Australia and 25 in Canada. The trends among the final list of 20 startups included: rise of the consumer; blockchain everything; race to autonomy; no office, no problem; engineers are in demand.

As an innovative contribution to and prospective beneficiaries from the SU startups program, we propose the creation in Scotland of a DLT-based AI-ML-Big Data-Analysis network to link a database of profiles of SU startups and LinkedIn Top Startups to databases of profiles of Scottish startups. Databases of Scottish startups that could be produced include: (a) entrepreneurial companies that have entered competitions for entrepreneur-adjudicated awards over the past decade; (b) science-based businesses; (c) businesses founded by the diaspora of Scottish entrepreneurs.

By way of possibilities, the Scottish EDGE competition identifies and supports Scotland's up-and-coming, innovative, high-growth potential entrepreneurial talent and businesses. From 2,705 applications in the past 10 years it has supported 313 entrepreneurial businesses as adjudicated by highly successful entrepreneurs. We propose assigning to a database up-to-date profiles of these businesses for DLT-linking to the SU database of startups.

Similarly, for angel funding provided to Scottish "scientists, technologists and business leaders who are not just talented and innovative people, but entrepreneurs seeking to transform their expertise into global businesses" as reported in the Summer 2018 issue of [RSE: Science Scotland - Start-Ups: Shaping Scotland's Future](#). Nine of many promising enterprises are very professionally profiled in this issue (with the promise of more profiles to follow), such as [MIME® Technologies](#) which "started as a high-tech solution to improve first response in medical emergencies in remote areas of Scotland" and is "now on the verge of talking flight in one of the world's biggest markets – civil aviation". Add to this the recently established [RSE Unlocking Ambition Enterprise Fellows](#) with inaugural awards made to 20 talented entrepreneurs selected from 40 entrants.

And for entrepreneurship in general, we have the ambition of [Entrepreneurial Scotland](#):

"Entrepreneurial Scotland, formed through the coming together of the Entrepreneurial Exchange and the Saltire Foundation, combines a substantial group of talent with plentiful opportunities, where the organisation aims to inspire and develop Scotland's people to build the most entrepreneurial society in the world."

In relation to the Scottish diaspora, it may be worth profiling businesses founded by the diaspora of Scottish entrepreneurs with a view to various forms of AI-based matching these with the foregoing startups and other existing and possible databases of Scottish startups. Interactions within the Scottish diaspora (i.e. intra-diaspora) could focus initially on where the greatest potential is likely to arise, for example, the London-based diaspora.

Other nations could be invited to provide access to similar databases, perhaps based on agreed business profile formats and filters (e.g. as per LinkedIn's up to seven years since start up and over 50 employees). By extending this to profiling the diaspora-based startups of these countries it may be possible to enact all manner of beneficial interdiaspora initiatives. As an example, the authors have interacted with a Maltese colleague¹⁵, online and in presence in Malta, about Scotland-Malta collaboration on the hydrogen economy and DLT empowerment opportunities. Like Scotland, Malta has considerable offshore wind energy potential and a strategically placed free port to benefit from large scale ammonia production for export throughout the Mediterranean. Unlike Scotland Malta may be earlier to embrace national scale DLT opportunities: [Malta as 'blockchain island' is 'calculated risk'](#), says Prime Minister Joseph Muscat.

4. Productivity Gains by Transitioning to Export Powerhouse

Central to achieving ever increasing productivity outcomes is extending the capacity for Scotland to increase massively its production of high value-added products for export by maximising gains from 3D opportunities. Yester years saw Scotland excel in the export of advanced engineering services, shipbuilding and heavy industry manufactures and medicine. For a much longer period, the Highlands and Islands complemented this with the export of essentially low-value, polluting products from the harvesting and processing of seaweed (e.g., soda ash and potash and the attendant release of carbon dioxide and methane from the burning process).

Today it is primarily whisky and tourism. It's not that Scotland is asleep to the opportunities of adding significant value to its natural resources. Initiatives include world-leading research in seaweed cultivation by the Oban-based Scottish Association for Marine Science, the production of high value products from seaweeds, producing advanced materials from [root vegetable "waste"](#), boosting an already significant [biomethane production](#) capacity as well as leading in the development and deployment of renewable energy technologies.

These and many other prospects for new high value-added products are considered for expansion to industrial and significant export scales through a proposed process of "eco-industrialising" the Highlands and Islands, a form of *industrial symbiosis* operating as a closed loop production cycle continuously improving environmental and economic outcomes. Of topical interest, as the UK Prime Minister heralds a 25-year plan to reduce plastic waste¹⁶, is the exciting prospect of producing a replacement for plastic packaging from seaweed, either biodegradable or edible¹⁷ packaging for a myriad for high-value products transforming local natural resources for export, all benefiting from the marketing glow of this form of packaging.

Scotland wide prospects include reviving the steel industry through an ambitious programme of producing decarbonised steel, a significant programme of building niche ships associated with harvesting and attending seaweed farms and larger scale vessels to rid the oceans and seas of ubiquitous plastic waste, and the large-scale export of machinery manufactures, initially required to produce an envisaged wide range of products for local and national consumption and export.

5. Proposed Papers

The working titles of the papers on proposed investigations, which represent an ambitious but nonetheless entirely achievable working programme, are as follows:

- 5.1 *Innovation in Building Social Capital to Maximise Well-Being*
- 5.2 *Hydrogen Scotland: A Route to Export Powerhouse*
- 5.3 *Investment in Demonstrations of Hydrogen Scotland Technologies*
- 5.4 *Investment in the Deployment of Hydrogen Scotland Technologies and Advances*
- 5.5 *Scoping the Extent of Eco-Industrialising the Highlands and Islands*
- 5.6 *Crofting as a Catalyst for the Hydrogen Scotland Development and Eco-Industrialisation*
- 5.7 *Greenprint for a Lead Community on the Isle of Skye*
- 5.8 *Appraisal of Manufacturing and Service Export Opportunities*
- 5.9 *A Business Case for Operating an Implementation Capacity on the Isle of Skye*
- 5.10 *Evaluation of the National Socio-Economic and Environmental Impacts*

¹⁵ Professor Joseph Falzon, Faculty of Economics, Management & Accountancy, University of Malta

¹⁶ Theresa May proposes [plastic-free supermarket aisles](#) in green strategy.

¹⁷ [Kelp packaging](#), [Edible seaweed packaging](#), [Plastic-from-seaweed](#).

5.1 Innovation in Building Social Capital to Maximise Well-Being

This paper focuses on the 'macro' backdrop to our work in terms of the well-known fall off in productivity, and its consequences for economic growth, in the UK and Scotland since the financial crisis, and the more secular productivity lag in Scotland vis a vis the rest of the UK and other European Countries. Many and various explanations for the slowdown in productivity have been given, from the quality of the supply of labour to the quantity and quality of capital investment, and these will be discussed in detail in this paper. Some have concluded that the financial crisis signals the end of the market-based economic model and have offered radical alternatives; for example Reed, [Rip it up and Start again: the case for a new economics](#):

"In some ways this moves us away from neoclassical economics and back towards the classical economics of Smith, Ricardo and Marx—although, of course, with much better data, and infinitely more computational power to crunch it."

"Finally, economics needs to be pluralistic. For the last half-century neoclassical economics has been gradually colonising other social science disciplines such as sociology and political science. It is high time this process reversed itself so that there was two-way traffic and a mutually beneficial learning exchange between disciplines. It is possible—and probably desirable—that the “deconomics” of the future looks more like psychology, sociology or anthropology than it does today’s arid economics."

Others focus on maximising the well-being of humans as crucially depending on maximising the well-being of the natural environment and the resources which sustains them. This is persuasively expounded by so called “renegade” economist Kate Raworth in [Doughnut Economics: How to Think Like a 21st Century Economist](#) which in recognising “economics as the mother tongue of public policy” underscores “the need for a new generation of economists who are ready to manage our planetary home”. As such she argues for a new model citing Buckminster Fuller:

“You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete.”

The Stockholm Resilience Centre system dynamics Earth3 Model¹⁸ (focussed on the planetary rather than national scale) seeks to evaluate the contribution of "5 transformational policies" through some form of conformal mapping of the UN's 17 Sustainable Development Goals (SDGs) within nine Planetary Boundaries (PBs) of scientifically delineated support systems to reach solutions "for a prosperous and sustainable world". Earth3 from the has been developed to evaluate the capacity of transformational policies for

- (1) rapid renewable energy growth
- (2) accelerated sustainable food chains
- (3) new development models in poorer countries
- (4) active inequality reduction
- (5) investment in education for all, access to work, gender equality, health, family planning

to attain the SDGs within the PBs across seven global regions.

The Earth3 Model applies an ensemble of models (comprising a climate module, a biosphere module, and a global economic model not to second guess each other but to harmonise algorithmically inputs and outputs between them integrating what has been described as “a whole room of fantastic accomplishments”. At the national scale could this approach be used to assess the contribution of transformational policies (such as radical taxation reforms pertaining to land value and decarbonisation) to attaining national goals of maximising individual, national and environment well-being subject to prescribed carrying capacities? Carrying capacities could include those of: natural resource endowments; the scale of human activity; human capital, social capital, educational attainment, technological prowess, intergenerational equity, culture as the force multiplier and so on.

It is interesting to note that the UK Office of Science report [Computational Modelling: Technological Futures](#) referred to earlier provides an extensive treatment of the role of system dynamics in various contexts. This includes: the original MIT based application of system dynamics to global modelling by Jay Forrester leading to the *Limits to Growth*¹⁹ project for the Club of Rome (page 20); in “participatory or group modelling” directly

¹⁸ The Ted Talk on this by sustainability expert Johan Rockström debuts the Earth3 model's evaluation of [5 Transformational policies for a prosperous and sustainable world](#)

¹⁹ Meadows, Donella H; Meadows, Dennis L; Randers, Jørgen; Behrens III, William W (1972). *The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind*

involving model commissioners and users (page 29-30) often embedded in well-established processes of scenario planning²⁰; to describe mechanisms underlying the transmission of norovirus through the human population (page 32); modelling complex emergent systems (page 41); the exploration of ‘what if?’ questions (page 47); improved understanding of the child protection system (page 63); management of building contractors (page 78); and an account of the methodology (page 42).

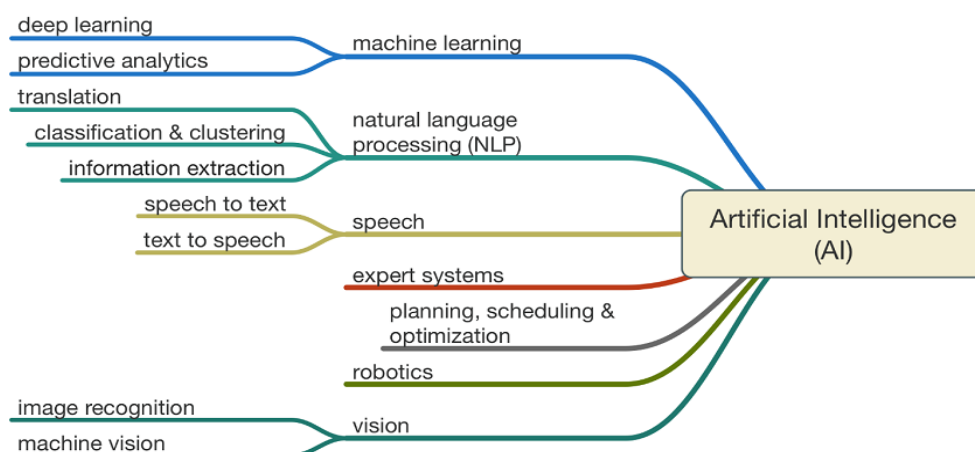
While there have been applications of system dynamics to modelling economic and finance systems this has not been referred to in the extensive section on Modelling in Finance and Economics (pages 89 -97). This is probably because modern economists have heavily criticised (perhaps more so than classical economists would have) the basis of the system dynamics models. Perhaps the most comprehensive critique stemmed from Nordhaus²¹ (1992) in relation to underestimating the capacity of ever advancing technology to ameliorate perceived adverse impacts of natural resource depletion and degradation, notwithstanding his inferences concerning the diminishing growth in productivity in developed countries in several decades to 1990 and now continuing on the whole over the ensuing three decades.

That said, a recent attempt has been made by [Steve Keen](#) (post-Keynesian and critic of neoclassical economics) to use system dynamics to model how swings in financial systems lead to financial crises based on explanations espoused by so called rebel economist [Hyman Minsky](#): *"Minsky", a Macroeconomic Modeling Software Platform*. *Minsky* is a free open-source computer program for building and simulating dynamic, monetary economic models without equilibrium and with a financial sector, in which banks, debt and money are indispensable, and in which the economy is always changing.

Entities seemingly in concert with Reed’s deconomics include:

- [Stockholm Resilience Centre: Earth3 Model](#)
- The [Centre for Rebuilding Macroeconomics](#)
- [Institute for New Economic Thinking: We advance sound economic ideas to better serve humanity](#)
- [Romer on “What went wrong with macroeconomics”](#)
- [IDEA – Dedicated to the reform of economics](#) established by Steve Keen “to educate policy-makers, the public and economists in Three Basics: debt matters, money matters and the economy is a dynamic system”.

With respect to these new forms of national and global models the computational power to conduct the deep learning algorithmic analysis of relevant “big data” sets and some of the techniques used in advancing AI (such as portrayed below)



What's required for a machine to be intelligent: [from AI Architecture Intelligence](#)

to harmonise the operation of ensembles of models will probably have to await the arrival of quantum computing²². This would encompass not only the requirements of market-based structures and the types of

²⁰ [Combining participatory scenario planning and systems modeling to identify drivers of future sustainability on the Mongolian Plateau](#)

²¹ William D. Nordhaus, *Lethal Model 2: The Limits to Growth Revisited*

²² See: “The Quantum Age: technological opportunities”, UK Government Office of Science (Nov 2016); and the work of [Australian of the Year, 2018, Michelle Simmons](#) and her research team are leading in the race to build a quantum computer capable of solving problems in minutes, which would otherwise take thousands of years. Such a discovery has the potential to revolutionise drug design, weather forecasting, self-driving vehicles and artificial intelligence.

techno-economic opportunities identified here but also the techno-sociological, the techno-ecological and the techno-psychological pathways to build the forms of social capital and social media in maximising well-being. The reader of this Overview will probably note the wide diversity and plurality of academic and information sources we have drawn on essentially recognises that the market-based model continues to thrive within and beyond the Anglo-Saxon world, suggesting that Reed's radical alternative to overcome the malaise may have to be assessed by a feasible new model, at least until the lead is in the hands of the computationally empowered new "generation of economists".

Indeed, in his influential book the *End of History*, Francis Fukuyama argues that the convergence of modern-day economies into market-based economies and their integration into the global economy suggests that the Marxist-Hegelian sense of history as a 'broad evolution of human societies advancing toward a final goal' has arrived. However, there is no doubt that in Anglo Saxon countries there is a questioning of the neoclassical economic paradigm that underpins much of the theoretical justification for the model. The underpinning assumption of purely rational self-interested behaviour, which is also reflected in the finance and macroeconomics literature in terms of the assumption of rational expectations hypothesis, have been questioned by many with various alternatives being proposed.

Although we do not advocate a dramatic move away from this paradigm we do believe that the literature on social capital, discussed above, suggests that a return to some form of the more traditional themes of political economy, a specialism still very much alive in Scottish Universities until comparatively recently, would pay dividends. For example, Adam Smith's writings are peppered with discussions of the fact that economic life very much meshes with social life and that the former cannot be understood without an understanding of morals, habits and customs. His thoughts have been formalised more recently by writers such as Fukuyama who has argued that although the standard neo-classical model gets human behaviour right about 80 per cent of the time, the remaining 20 per cent can only be understood by understanding culturally related factors and central to this is the concepts of social capital, cultural norms and trust.

The concept of social capital seems to have been entirely missed in the current UK and Scottish debate about boosting productivity and economic growth and so the main theme of this paper is to reintroduce a discussion of the concept and related concepts and how they may improve well-being in the broadly defined usage here.

5.2 Hydrogen Scotland: A Route to Export Powerhouse

This paper, the starting point of our discussions on economic development, focuses on a "game-changing" opportunity for Scotland in general and the Highlands and Islands in particular arising from a recent breakthrough in markedly reducing the cost of extracting hydrogen from ammonia and renewable energy generated ammonia. This results from technological advances accelerating reductions in the costs of renewable energy for the production of ammonia. Game changing in the sense that the opportunity holds the potential for Scotland to exceed the maximum annual levels of energy extracted from North Sea oil & gas in perpetuity. And to do so in cost-effective, sustainable, and ecologically enhancing ways as innovative efforts are made to extend the life of existing oil & gas fields while simultaneously realising commercial returns from decommissioning these fields.

The vast quantities of ammonia envisaged could be exported in two major ways. The first envisages shipping the renewable ammonia as a carrier of hydrogen to countries already gearing up to become major hydrogen users by using the technology for low-cost extraction of hydrogen from the ammonia and using it within the existing distribution systems for oil and gas, either directly or by supplementation of the provision of natural gas. The second envisages the production of wind energy from vast floating wind farms in the Atlantic and North Sea delivering electricity into a proposed European Offshore Supergrid as envisaged by wind energy entrepreneur Eddie O'Connor in [An Engineering Vision for a New Europe](#). The production of ammonia when Supergrid demands are low would circumvent the usual criticism of renewable energy intermittency. It is envisaged that the plant for the ammonia production could be located on disused oil rigs located throughout the wind farms, with ammonia storage in below surface tanks supporting rig stabilisation. In this way when winds are lower during Supergrid peak demand periods energy supplementation could be achieved through low cost extraction of hydrogen from stored ammonia which in turn would produce electricity for the Supergrid using ceramic fuel cells. The other main criticism concerning energy transmission losses may also be

circumvented by the time the planning of this initiative is complete. This arises from the recent breakthrough in the use of graphene to reduce energy transmission losses to near zero²³.

References are also made to the need for many communities across the Highlands and Islands to be involved actively in the build, own and operate activities of the massive wind power installations proposed, whether onshore, offshore or floating. In as far as existing wind farms can be extended, it is also proposed that these communities will benefit from the availability of the ever-lowering cost of renewable energy to enrich existing and establish new settlements with the capacities to produce high-value products from local natural resources for local consumption and large-scale export outcomes.

We believe there is a clear opportunity today to have a relatively low-cost pilot in a suitable Highland based location. This is due to the existence of Constraint Payments that currently exist and in the current year amounted to £100m. These are compensation payments made by the national grid to owners of wind farms, predominantly in Scotland, because at certain times of peak wind there is a surplus of renewable energy being produced and the wind farms have to be shut down and such payments have resulted in energy bills being more expensive than they need be. The storage of hydrogen in the form of ammonia offers a way of storing this excess renewable energy that can then be released into the grid at a more suitable time or perhaps used in more local contexts along the lines of our discussions in section 5.5 and section 5.6.

Consideration could be given to doing this in adjoining industrial parks that optimise an association between two or more industrial facilities or companies in which the wastes or by-products of one become the raw materials for another. This form of industrial symbiosis, or eco-industrialisation, seeks to emulate the processes of ecosystems in nature in what are commonly referred to as eco-industrial parks (EIPs). In reviewing locations for these communities and EIPs the suitability of extending existing wind farms would be assessed.

In relation to building attendant social capital, Germany as an export powerhouse has 4.1 primary care doctors and 8.2 per 1,000 people compared with the UK's 2.8 and 2.7 respectively, with Germany expending 11% of GDP compared with the UK's 9% as reported by the OECD. The rural numbers in Scotland are of course much worse with the newly defined health care area in Highland region of Skye, Lochalsh and South West Ross only having a figure of 1.6, very much in the developing country league. And converting to opportunities the threats recently reported in The Times:

- [Diluting teacher training standards](#)
- [Rise of robots puts 230,000 Scottish jobs under threat](#)
- [Lack of well-paid jobs leading to brain drain, tycoon Jim McColl warns](#)

5.3 Investment in Demonstrations of Hydrogen Scotland Technologies

This report will investigate the feasibility of attracting investment in prototype demonstrations of existing, emerging and future technologies to produce ammonia from renewable energy sources at many sites throughout the Highlands and Islands. It is envisaged that this will involve extensive consultations with communities, technologists and enabling corporates in conducting investigations similar to those recently undertaken and published in Australia:

The National Hydrogen Roadmap

- Provides a blueprint for: (a) the development of a hydrogen industry in Australia by synthesising existing investigations that have quantified hydrogen-based economic opportunities; and (2) how to realise these opportunities, particularly by informing stakeholder groups (e.g. industry, government and research) on collective investments supporting industry to scale in a coordinated manner.
- Identifies barriers to market activation stemming from a lack of supporting infrastructure and/or the cost of hydrogen supply which can be overcome via a series of strategic investments along the value chain from both the private and public sector.
- Demonstrates that while government assistance is needed to kick-start the industry, it can become economically sustainable thereafter by: (a) assessing the target price of hydrogen needed for it to be competitive with other energy carriers and feedstocks; (b) assessing the current state of the industry, namely the cost and maturity of the

²³ [Surprise graphene discovery could unlock secrets of superconductivity](#), Nature, March 2018

underpinning technologies and infrastructure; and (c) identifying the material cost drivers and consequently, the key priorities and areas for investment needed to make hydrogen competitive in each of the identified markets.

- Determines that the opportunity for hydrogen to compete favourably on a cost basis in local applications such as transport and remote area power systems is within reach based on potential cost reductions to 2025.
- Highlights that “the development of a hydrogen export industry represents a significant opportunity for Australia and a potential ‘game changer’ for the local industry and the broader energy sector due to associated increases in scale”.

The roadmap is available to download as an [Executive summary](#) or as a [Main Report](#).

Opportunities for Australia from Hydrogen Exports

- Australian hydrogen exports could contribute \$1.7 billion per annum to the economy and provide 2,800 jobs by 2030
- Japan, China, Republic of Korea and Singapore are prospective markets for Australian hydrogen by 2025
- While countries like Japan and Korea look to decrease emissions and increase renewable options, they are looking to import hydrogen at large scale but there are as yet no exporters
- But Australia is not alone, as countries like Norway, the United States and Middle Eastern countries are also likely to scale up their capability to export hydrogen
- “The sector is still in its infancy which places Australia in a prime position to utilise its abundant renewable resources, as well as proven track record of exporting energy and strong relationships with energy importers to become a major player in exporting hydrogen to Asia and around the globe,”
- A hydrogen export market has also been identified to benefit regional communities as hydrogen production facilities are likely to be located close to the supply of renewable energy

This report is available to download as [Press Release](#) or as a [Main report](#)

These reports were part funded by the [Australian Renewable Energy Agency](#) (ARENA) and provided the basis of Australia’s [Hydrogen Strategy Group](#) (chaired by the Chief Scientist) presentation to the COAG²⁴ Council of Energy Ministers and led to approval of a \$22 million funding boost from ARENA to sixteen “hydrogen-export” research teams in nine universities and research institutions.

Given its preparation of the paper “Hydrogen Scotland: A Route to Export Powerhouse” as outlined above, it is proposed that HIAIAlba conducts the necessary consultations with Scottish government agencies and companies (e.g. through the [Scottish Hydrogen and Fuel Cell Association](#)) to secure the funding to prepare similar reports for Scotland. These reports among other things will identify critical R&D supporting a proposed Scottish drive to develop a hydrogen export industry and to provide the basis for consultations with energy majors on the envisage investment in the proposed prototype demonstrations throughout the Highlands and Islands.

We note that the Scottish Government in its “2050 vision for energy” as reported in its January 2017 report [Scottish Energy Strategy: The future of energy in Scotland](#) covers many prospects for the role of hydrogen in the national energy mix. However, it neither envisions it as a major export industry nor considers the role of renewable ammonia in achieving this outcome. The report asks the question: What ideas do you have about how we can develop the role of hydrogen in Scotland’s energy mix?

This Overview and our *Hydrogen Scotland* paper provides our response.

As reported by [Scottish Development International](#), while Scotland and Norway through Equinor have collaborated in the development of [Hywind](#)²⁵ the first offshore wind farm in the UK, it should be noted that Norway is already exploring the prospects for hydrogen as an export industry: [Norway races Australia to fulfill Japan's hydrogen society dream](#). Do we compete or collaborate as with Hywind? Do we explore markets throughout Europe, the Middle East, Africa and South America?

A detailed assessment of a prospective testing site on the Isle of Skye will be provided as the starting point of this project.

²⁴ COAG - Council of Australian Governments of the six states and two territories.

²⁵ A joint venture of [Equinor](#) (75%) of Norway and [Masdar](#) (25%) also known as Abu Dhabi Future Energy Company

5.4 Investment in the Deployment of Hydrogen Scotland Technologies and Advances

The feasibility of attracting the massive investment to build, own and operate the renewable energy capacity to produce and export ammonia on a game-changing scale at multiple sites throughout the Highlands and Islands and beyond. This will involve consultations with communities, technologists and enabling corporates at many sites throughout Scotland and the Highlands & Islands. Initially, indicative assessments of, say, 25 prospective sites for the Highlands & Islands will be provided. By game changing we mean onshore wind energy farm developments delivering in the order of 500MW at each location and resulting in the production of a significant export capacity in the form of hydrogen stored in the production of ammonia. Some 25 such developments would more than double Scotland's existing wind energy capacity. Offshore wind farms delivering a great many times this capacity could rank Scotland as a major global exporter of stored renewable hydrogen.

5.5 Scoping the Extent of Eco-Industrialising the Highlands and Islands

The paper will provide the results of a study into producing high-value existing and new products from the sustainable use of local natural resources throughout the Highlands and Islands for local and regional consumption and for large-scale exporting. Low and increasingly lower costs of renewable energy from the "Hydrogen Scotland" developments will be a key driver of increasingly effective and efficient symbiotic operations within and between enterprises focussed on the production of high value-added goods that can compete in national and global markets.

In addition to clean air and water and cheap renewable energy for ammonia production, preliminary consideration is being given to the use of natural resources such as seaweed, peat and bog iron. The return to these resources after so many decades may seem rather out of place in today's digital era, however, as noted above this crucially keys into initiatives such as producing packaging from kelp and the myriad of kelp-based products noted below, all relying on digital technologies to be delivered with high productivity.

Worldwide there are concerted efforts to harvest seaweed sustainably and to achieve environmentally enhancing outcomes such as the foray into manufacturing substitutes for plastic packaging noted above. This recent [ABC Catalyst video](#) "investigates how seaweed is helping to save the world - from growing the foods of the future, helping save the reef and even combating climate change". This FAO report provides an [Introduction to Commercial Seaweeds](#).

High value products from seaweed include:

- a) A myriad of food products such as [kelp caviar](#) and from Scotland a widely exported award-winning range of [vegan "cheese"](#) (Sheese) using kelp-extracted agar agar and carrageenan.
- b) AlbaVegan? – Quite frankly, clean-green Scotland is well placed to export a burgeoning range of vegan food products (mainly using local natural resources, including nutritious seaweed oil) of higher quality than nearly all of the suspect-oil²⁶-based vegan products being pushed in global markets. Do it right and sky's the proverbial limit, especially as it costs no more. The US vegan products' market alone is now \$22B with statistics on China's demand growing at over 17% p.a. for the last 5 years. The 2015 [World Health Organisation report](#) on the carcinogenic risks of eating red and processed meats is leading to major vegan-orientated revisions of national food guidelines, but this does not include the NHS which only recommends a 25% reduction in consumption of red and processed meats. Import replacing the avalanche of processed and junk foods would provide the basis for rapid growth of Scotland-based global corporates in this space.
- c) Craft beer – [kelpie seaweed ale](#) - "My favourite beer. Ever. It's rarely seen in my part of the States, but when I find it, I buy up all I can."
- d) [Healthcare](#) - Already a staple in many Asian cuisines, kelp is a natural source of essential vitamins, minerals, and antioxidants.
- e) [Cosmetics](#) – e.g. La Mer, Estée Lauder Companies and body balms from the [Isle of Skye Seaweed Co.](#)
- f) High quality leather produced from [kelp](#) (with traditional leather manufacturers having to compete with more eco-friendly and humane alternative materials) and [jellyfish](#).
- g) [Biofuels](#) – obviating severe adverse economic, environmental and social impacts of using food crops to produce biofuels driving up global prices in a world where a billion people are already hungry.

²⁶ [Effect of canola oil consumption on memory, synapse and neuropathology in the triple transgenic mouse model of Alzheimer's disease](#), Nature, Scientific Reports, volume 7, Article number: 17134(2017)

- h) [Advanced materials](#) - carbonization of kelp in an ammonia atmosphere to produce enriched 3D porous carbon for supercapacitors of high volumetric capacity.
- i) [Nanotechnology](#) – kelp extracts to produce low cost solar cells.
- j) [Revolutionary feedstock for cattle to reduce to near zero their methane excretions](#).

In relation to seaweed harvesting, consideration is given in the Hydrogen Scotland paper to the prospect of operating large-scale seaweed harvesting operations in conjunction with disused oil rigs and associated offshore wind farms established for offshore ammonia production. This would build on and extend the current [revival in Scotland of wild seaweed harvesting](#)²⁷.

Other less obvious natural resources for transformation to high value export products include peat, bog iron and limestone for cement:

- a) There are claims for products from peat that are 100 times more valuable and less invasive than horticultural uses – see, for example, [Peat could be northern Minnesota's newest cash crop](#).
- b) From way left-field, bog iron is considered in a preliminary version of the Hydrogen Scotland paper for renewable energy electrification of pollution-free steelmaking as a possible input to local manufacturing of low-cost, larger and more efficient windmill blades and as a catalyst in a new technology to convert onshore natural gas into hydrogen and graphite.
- c) 3D printing of houses for less than \$10K – [video](#) & [article](#) – using on-croft grown hemp for the production of fibre and hurd used to produce carbon negative hempcrete for onsite/on-croft building (see [hempcrete in building](#)²⁸ and [Mirreco](#)²⁹). Then consider making these houses autonomous with a larger flat roof surface serving as a water tank to catch rainwater and providing additional outdoor living space. Add to this [3D printed ultra-low cost, high efficiency solar panels](#) on the flat roof and the external walls clad with sheets of [3D printed solar cells, using seaweed extracts](#). The 3D printed versions of these [roof mounted wind turbines](#) (perhaps adapting this [3D printing process](#) for large blades) would then generate more than sufficient supplies of energy regardless of the weather, especially if the cost of battery storage continues to plummet, possibly with this [seaweed-based advance](#). Provide a 5G service and the occupants can interact at ever more advancing levels of communication/data-sharing/computation with any groups anywhere and elder citizen occupants can be supported by an ever-increasing efficacy of telehealth monitoring and supporting drone services.

Consideration will also be given to the work and projects of the United Nations University sponsored [Zero Emissions Research & Initiatives \(ZERI\)](#) as espoused in their philosophy of action:

- a) Where the best for health and the environment is cheapest and the necessities for life are free thanks to a local system of production and consumption that works with what you have.
- b) "Innovative business models" are capable of bringing competitive products and services to the market responding to basic needs while building social capital and enhance mindful living in harmony with nature's evolutionary path.
- c) "Competitiveness" is harnessing and optimizing the innate virtues and values connecting untapped local potential - like a natural system, where the seeds lie fallow only to sprout with amazing vigour at the first rain unleashing joy and happiness as the conditions for mindful living are met in balance and in harmony.

Also worthy of active consideration in this context is the 1973 and 1999 versions of Schumacher's *Small Is Beautiful: A Study of Economics as If People Mattered*, ranked by *The Times Literary Supplement* as among the 100 most influential books published since World War II. Schumacher (some may say ironically was Chief Economic Adviser to the National Coal Board for 20 years) espouses a philosophy that grew out of his study of village-based economics, casting education as the greatest resource and refuting platitudes about Capitalism as a social order concluding with advice to socialists:

²⁷ [Wild Seaweed Harvesting: Strategic Environmental Assessment - Environmental Report](#), November 2016

²⁸ Hemp is an excellent growth crop with many farming and environmental benefits: (a) hemp crop produces nearly 4 (four) times as much raw fibre as an equivalent sized tree plantation; (b) trees take approximately 20 years to mature... Hemp takes 14 weeks. (c) hemp needs no pesticides because it is unpalatable to insects; (d) hemp needs no herbicides because it grows too quickly for any weed to compete; (e) hemp can grow in virtually any climate and soil condition, and is excellent for reclaiming otherwise unusable land; (f) hemp crops rejuvenate poor soils; (g) Between 1.7 – 1.9 tonnes of CO₂ is absorbed from the atmosphere for each tonne of hemp cellulose produced (typically 10 tonnes of hemp straw per hectare is grown).

²⁹ Mirreco has developed a specialised machine that can process an entire hemp plant into separate items that are individually valuable such as seeds, fibres and the hurd. The company intends to manufacture, sell and/or own and operate a fleet of mobile machines to process hemp onsite at farming locations and to manufacture building panels for housing solutions using hemp biomass.

"Socialists should insist on using the nationalised industries not simply to out-capitalise the capitalists -- an attempt in which they may or may not succeed -- but to evolve a more democratic and dignified system of industrial administration, a more humane employment of machinery, and a more intelligent utilization of the fruits of human ingenuity and effort. If they can do this, they have the future in their hands. If they cannot, they have nothing to offer that is worthy of the sweat of free-born men."

And recently, this from [McKinsey](#) in assessing the competitiveness of small-to-medium metal and mining projects: small doesn't mean unprofitable; unlocking new value from small-to-medium metal and mining projects; managing smaller projects with increased rigor and a through-cycle mentality can help companies to capture significant untapped value.

Continuing this small is vital theme we envisage each eco-industrial park offering opportunities for startup research projects akin to the "[pop-up bio-lab innovators](#)" currently operating as [Open Cell](#) from 45 shipping containers in London's Shepherd's Bush market. – perhaps from ever more innovatively customised 3D printed premises. These businesses could be not only involved in advancing the types of product innovations identified above but also taking an active role in delivering industrial symbiosis across each eco-industrial park.

5.6 Crofting as a Catalyst for Hydrogen Scotland Development and Eco-Industrialisation

The feasibility of creating a system of *innovation and public purpose* governance, as referred to above, based on crofting and existing crofting settlements performing a key catalysing role at various scales of effort³⁰ :

- a) Individual crofts and clusters of crofts producing cash crops for processing in eco-industrial parks (EIPs) into value-adding export products as noted above and, in some cases, doing so through: (i) the use of *drones and robotised farming practices*³¹; (ii) leading-edge *permaculture*³²; (iii) *afforestation*³³ activities; (iv) on-croft growing and processing of hemp for seed (superfood for global distribution in seaweed packaging as [hemp milk best homemade](#), as hemp beer, hemp chocolate and hemp oil, as [CBD oil](#) for possible pain management of many medical conditions, fibre and materials for 3D printing of low-cost quality homes as noted above; and (v) hosting education and training programs for young developing country farmers³⁴ and students with high leadership potential.
- b) Crofting communities operating as major players in the establishment, delivery, and operation of the proposed massive renewable energy and ammonia-hydrogen production projects and providing inputs to as well as the operations of the envisaged EIPs;
- c) Networking between crofting communities and businesses (benefiting from ever increasing levels of information and communications technologies including distributed ledger technologies to determine and foster synergistic interplays between EIPs).

Meet the new generation of young crofters in this [video](#) and if in any doubt about this catalytic force, note the wisdom of the young crofter at 12.38: "Crofting is always evolving and it always has done and that's something that history shows us that crofting has always changed, always adapted and we shouldn't be afraid to do that."

Consideration could be given to 3D printing of houses (as considered above) on crofts to house: (a) young family members; (b) working visitors; (c) developing country students/farmers receiving an education & training in farming/crofting/permaculture/afforestation, perhaps obtaining the University of the Highlands and Islands (UHI) [certificate in crofting](#); (d) small communities of elderly citizens moving from acute hospital beds to community care and the therapy of participating in permaculture and afforestation activities. Another prospect could be UHI based research on 3D to produce designs for 3D house printing machinery (for central belt manufacturing) and software drivers and leverage this into a significant R&D 3D printing program.

³⁰ It may well be that the proposals referred to here and elsewhere in this overview may most readily set up in crofting communities in the Highlands and Islands that have recently gone into community ownership. A key impact of such community ownership is the way it has created collective and individual self-confidence thereby unleashing all sorts of entrepreneurial and other energies and adding to social capital. This additionally demonstrates the developmentally beneficial effects of decentralised and inclusive approaches that we refer to in the overview. We are grateful to Prof Jim Hunter for these points.

³¹ [Drones and Robots: Revolutionizing Farms of the Future](#) and from [Compute Scotland](#): robotic and drone technologies are playing increasing roles in raising the productivity of agriculture in Scotland.

³² [Skye Permaculture](#) recently morphed into [Earth Ways](#) - building a permaculture community with a significant training capacity.

³³ [Afforestation](#) creating on-croft crop-bearing native woodlands for local consumption and value-added EIP products and using common lands to [balance economics, carbon and biodiversity of peatland forestry](#), notably recycling scrap timber as high value [scrimber](#) - (a) and (b).

³⁴ McKinsey articles on agricultural transformations in developing countries – (a) and (b) – justify the case for such training programmes.

In assessing innovation in taxation reform, we envisage that crofting communities could provide an ideal test bed for well-designed, community-driven programs. In addition to possible 3D era innovations in tax reform earlier identified, there emerges this message from the Intergenerational Commission, Tax and Welfare, March 2018: [“Baby boomers are going to have to pay more tax on their wealth to fund health and social care,”](#) stemming from the Prime Minister’s concern of “a growing divide between a more prosperous older generation and a struggling younger generation.”

In traversing an impressive range of prospects for “what can be done?” in [The Crofting Problem](#) (1953), Collier refers to the need for enabling social capital. We will review these prospects in relation to envisaged proposals to be appraised in the “Eco-Industrialising” paper. The article [Why crofting is so important to owners of professional firms](#) refers to the establishment of Inksters, a law firm acting with successful differentiation by providing legal, including crofting law, services throughout the Highlands and Islands. This augurs well for all manner of services that can be delivered at home and abroad, collectively on an industrial scale across the Highlands and Islands, increasingly through advances in information and communications technology, including AI, machine learning and DLT. Similarly, for the manufacture of goods as considered above through advances in these technologies as well as robotics, drones and 3D printing.

5.7 Greenprint for a Lead Community on the Isle of Skye

Imagine a new town of up to 10,000 residents integrated with a crofting community actively involved in the local and regional delivery of “Hydrogen Scotland” and eco-industrial developments. Wind power is generated on croft lands or offshore to meet town and surrounding community needs and as the base for a major export facility to produce ammonia from air and water. This power also provides a low-cost input to competitive production of high-value products from local and regional natural resources at a centrally located eco-industrial park (EIP): goods that are produced for local and regional consumption and to meet growing export demands as envisaged in the “eco-industrialising” and “crofting as a catalyst” papers.

This paper will envision such a development at a location to be determined on the Isle of Skye as an important example for the Skye community but also one that can be replicated beyond to other Highland and Scottish communities. It will be drafted in close consultation with all communities of interest. One of the authors has extensive experience in consulting on the design and assessing the social benefit-costs of such developments as noted in this [bio](#). This includes reference to a proposed “eco-technopolis” development for 75,000 residents near Port Macquarie in Australia, referred to as the Hastings 2000 Project, documented in the submission [Urban Living in a Natural Environment](#) to the New South Wales Government. Among other things, this report describes a process of internalising increasing land values for the benefit of all residents.

It is interesting to note that Paul Romer, a winner of the 2018 Noble Prize in Economics, has been making a case for building large-scale chartered (i.e. radical new rules based) cities in many locations throughout the developing world. In our case the cities would be on a smaller scale but also based on new rules determined by community-based appraisals of innovative taxation reforms as foreshadowed in the *Crofting as a Catalyst* paper.

5.8 Appraisal of Manufacturing and Service Export Opportunities

There are a wide range of other opportunities involving decarbonised steelmaking, boosting ship building, large-scale manufacturing and exporting of advanced machinery, and the export of IT-based network services that would arise from the implementation of the prospects reviewed in the Hydrogen Scotland paper.

These include:

- a) Central Belt decarbonised steelmaking, ship building and manufacturing of advanced machinery:
 - i) Manufacturing revolutionary new machinery for low cost extraction of hydrogen from ammonia-to hydrogen;
 - ii) Manufacturing Solid-State Ammonia Synthesis (SSAS) machinery for renewable-ammonia production (not only for numerous Highland & Islands wind farms but also for a prospective worldwide boom in renewable-ammonia-hydrogen production) possibly using additive manufacturing (3D printing) and thereby putting Scotland in the vanguard of large-scale manufacturing and exporting of 3D printing machinery and enabling software;

- iii) In situ carbon-neutral production of hydrogen and graphite from onshore natural gas reserves using a revolutionary new technology referred to as the [Hazer Process](#), currently being commercialised;
 - iv) Carbon-negative production of hydrogen and graphite by biomethane collocating the Hazer Process with many biomethane production operations throughout Scotland;
 - v) Manufacturing Hazer machinery for European and African markets;
 - vi) Manufacturing machinery for new technology to convert [Hazer graphite to graphene](#) and the subsequent transformation of graphene into high temperature superconductors³⁵ for use, among other things, in reducing the dissipation of electrical energy transmission to near zero;
 - vii) Decarbonised steel production (i.e., renewable energy-based and Hazer processed hydrogen from natural gas to electricity to power electric arc furnaces) in an ambitious revival of Scotland's once formidable steel industry – see [proposed CGF in operation to melt scrap steel in Scotland](#);
 - viii) Given the foregoing, a case could be made for accelerating quantum computing research into mapping underground hazards in onshore extraction of natural gas, such as detection of the risk of earth tremors - see [The Quantum Age: technological opportunities](#), UK Government Office for Science, November 2016. So as [“Britain gets fracking – After a long delay, fracking resumes in Lancashire”](#) as reported in *The Economist* (Oct 2018) and [‘Fracking earthquake limits ‘may be too strict’](#) as reported in *The Times* (Jan23, 2019), it would appear to be in the interest of frackers to fund this risk assessment research effort as well as accelerating the commercialisation of the Hazer process and its attendant spin-offs as proposed in the foregoing. Indeed, it could be a policy position of government based on harnessing feedback from all communities-of-interest that fracking gets the go ahead if and only if....
 - ix) Building ships to harvest and tend large-scale seaweed farming operations on a scale dwarfing the workload of the Scottish fishing fleet;
 - x) Building ships to collect sea-borne plastics, initially from the seaweed farms and subsequently from UK and European waters;
 - xi) Building very large autonomous, ocean-going vessels to not only collect sea borne plastics such as exist in the massive patches (3 time the size of France) swirling and growing in the Pacific Ocean but also to convert the plastics to minimal pollution biofuels³⁶ on board and thereby power the vessels indefinitely;
 - xii) Autonomous drive refuse collection vehicles (RCVs) running on biofuels³⁷ produced real-time from the plastics and bio-wastes collected, noting the existence of Dunfermline-based [Hillend Engineering](#) as one of the most advanced manufacturers of a wide range of RCVs in Europe with regular exports to many European countries;
 - xiii) Building largely autonomous, ocean-going vessels to transport ammonia, and powered by hydrogen extracted from ammonia with wave energy and wind energy from utility-scale [kite-generated electricity](#) used to produce replenishing ammonia *en route*.
 - xiv) Building Roll-On Roll-Off (RORO) ships powered as for xiii) to export autonomous RCVs at xii).
- b) DLT-based establishment and operation of renewable energy networks for not only renewable-ammonia-hydrogen production and distribution but also for grid-based distribution - by bedding this down for the mega ambitious Highlands & Islands renewable energy development programme, say from administrative bases in Inverness and Aberdeen, there is every prospect that this could be delivered globally as well – that is Scotland wide propagation of Software as a Service (SaaS) on a massive scale.

The forthcoming Hydrogen Scotland paper identifies and briefly considers several other prospects to boost the export of high value-added goods and services from Scotland which will be reviewed and evaluated in detail in this appraisal.

5.9 A Business Case for Operating an Implementation Capacity on the Isle of Skye

The authors recently produced a discussion paper on improving the tourism infrastructure of the Isle of Skye which outlined a case for a multipurpose building referred to as [Skye IDEA](#) (page 34), featuring among other things: a world-class climbing wall; capacities for attracting entrepreneurs and innovative enterprises; a

³⁵ [Surprise graphene discovery could unlock secrets of superconductivity](#), Nature, March 2018

³⁶ [Licella's Catalytic Hydrothermal Reactor](#) (Cat-HTR™) takes 20-30 minutes to create a renewable biocrude oil from plastic waste.

³⁷ Both the proposed ship and RCV applications of Cat-HTR™ are considered further in the *Hydrogen Scotland* paper.

business incubation centre to producing designs for 3D printing machinery (for central belt manufacturing) and software drivers; research activities supporting EIP initiatives, in particular processes for reaching agreement on the governance arrangements for the proposed new towns throughout the Highlands & Islands drawing on sources such as the Highland Council, the Crofting Commission, the Scottish Crofters' Federation and the Institute for Innovation and Public Purpose.

The business case for this centre would draw on the investigations and the results of consultations pertaining to the foregoing papers. An outline is provided in the preliminary version of the "Hydrogen Scotland" paper.

5.10 Evaluation of the National Socio-Economic and Environmental Impacts

Drawing on a comprehensive social-benefit cost analysis and assessments of the increased productivity flowing from the effective urban design of the proposed new town development on the Isle of Skye, an assessment can be made of the national benefits of replicating this at multiple sites throughout the Highlands and Islands, say, 10, 25, 50 times. This has been done using a computable general equilibrium model (CGEM) for a 25-fold replication of the proposed Hastings 2000 Project and reported in [Assessing the National Economic Impacts and Benefits of Decentralised Development Through Hastings 2000 Projects](#).

In addition to assessing the national impacts of multiple Highlands and Islands communities, the proposed CGEM application could include assessments of the increased productivity flowing from the wide range of manufacturing and service export activities noted below.

6. Regional Contributions to Raising Productivity and Powering Export Performance

The report [Scotland's economic performance - comparative research](#) provides comparisons of Scotland's productivity with OECD countries and comparisons of four Scottish regions (North Eastern Scotland (NES) - Eastern Scotland (ES) - South Western Scotland (SWS) - Highlands and Islands (HI)) with EU regions.

This Overview outlines development scenarios indicating how the productivity of these four regions could be raised to the level of Norway:

- NES (70% increase in productivity to equal Norway) - offshore wind farms and for renewable ammonia-hydrogen production and exporting together with associated major seaweed harvesting zone developments could enhance the relatively high performance of NES as offshore oil & gas exploitation declines.
- ES (144% increase) - based on realising a plethora of manufacturing opportunities identified above, with possible onshore exploitation of natural gas (map of [central shale belt](#)), as per: (a) [Scotland pressed to exploit onshore oil and gas reserves](#) and (b) [Significant economic benefit for Scotland can flow from lifting unconventional oil and gas exploration moratorium](#) if and only if this can be done *in situ* with carbon-neutral electric-arc-furnace steelmaking using e.g. Hazer technology and/or renewable ammonia-hydrogen production (using SSAS ammonia technology) and ceasing huge subsidies to the coal and natural gas industries hoping that they will eventually deliver Carbon Capture & Storage (CCS) solutions; highly innovative proposals for niche but large scale ship building to clear seas and oceans of plastic and related wastes.
- SWS (144%) - This region but could be developed as for HI re eco-Industrialisation and eco-newtowns with electricity generated from hydrogen that has been extracted from ammonia shipped to the region from HI ports obviating the need for wind power farms and visually polluting transmission pylons striding the landscape (as convincingly opposed [here](#)). This could be supplemented by a considerable tidal power plant at the Solway Firth producing ammonia-hydrogen for Kircudbright, Castle Douglas, Dumfries and Lockerbie and smaller scale tidal power stations serving the coastal towns from Ardrossan to Stranraer with the possibility of Kilmarnock and Lanark becoming major centres for the manufacturing of tidal energy plant and equipment and tidal plant development services with a view to putting Scotland at the forefront of harnessing tidal power - (see 2017 article on [The wave and tidal resource of Scotland](#)). Add to this the recent Kilmarnock-based project³⁸ to harness geothermal energy for district heating conceivably leading to similar developments adjoining settlements throughout SWS, conceivably resulting in prospects for startup ventures in geothermal energy provision and services UK wide and beyond.

³⁸ [Supported by a £1.8m of grant from the Scottish Government's Low Carbon Infrastructure Programme and the European Regional Development Fund](#)

- HI (159%) - Renewable Ammonia-Hydrogen exporting; Eco-Industrialisation and eco-newtowns with crofting (interaction within and between crofts, crofting communities, crofting communities' regional cooperatives, inter-regional cooperation) as a creative commons' catalyst.

An "imagination creates reality"³⁹ challenge then could be how to grow Glasgow-Edinburgh (47 miles apart) into a conurbation on the scale of Greater London (45 miles across) and increasing productivity by 500% to match it - simultaneously climbing 45 places to match Switzerland at the top of the [European Innovation rankings](#). Possibilities for the development of export industries include:

- Rapid growth in renewable electric steelmaking and "ocean clean-up" shipbuilding and other niche shipbuilding opportunities as indicated above – in Leith (?) as well as Glasgow shipyards.
- Becoming a world leader in [hyperloop](#) technology by using it to emulate the London Underground and export leveraging accordingly - and linking with the proposed [Virgin venture](#) of London to Edinburgh in 45 minutes.
- Pipelining renewable ammonia from North Sea operations to produce hydrogen for fuel-cell to electricity for transportation throughout the conurbation, including trucking, bus and train networks, and the hyperloop network and exporting the production of enabling machinery and services as outlined in the Hydrogen Scotland paper.
- Growing Scotland's financial services sector of 85,000 people and information technology related industries of 100,000 people into, among other things, a world leading fintech industry by developing a major global presence in DLT-based services, initially by supporting the applications identified in the foregoing as well as banking, insurance and funds management, and subsequently leveraging of this into exporting services approaching the scale of [London's financial services sector](#) and the 750,000 people it employs, perhaps growing at a rate in excess of the 15,000 new fintech roles in Scotland in the next 10 years predicted by the [Centre for Financial Regulation and Innovation](#).
- As outlined in the Hydrogen Scotland paper, embracing vertical farming throughout the conurbation (initially exploring the claims from [AeroFarm](#) that it has achieved plant growth that is 390 times more productive per square foot than a commercial field and from [VertiCrop](#) using a hydroponic technology in vertical farms with the claim of 20 times more yield than open field agriculture) to feed a burgeoning population and leverage the acquired knowledge into exporting enabling machinery manufactures and services.
- Imagine a conurbation with high productivity in high-value manufacturing as well as globally demanded high-value services that largely feeds itself – and consistently rates as the world's most liveable city.

The CGEM analysis proposed in Paper 10 above could also be applied to assessing the socio-economic and environmental impacts of the four regions and the conurbation.

As foreshadowed in the outline for Paper 1 we may have to await the advent of quantum computing to determine how to maximise the creation of well-being (in particular, policies to decrease inequality) of Scotland's people and the resources and environment that sustains them subject to attaining levels of productivity and economic growth in its four sub-regions comparable with that of, say, Norway. Conceivably this will facilitate transcendence from *ad hoc* policy incrementalism to conceiving, evaluating and implementing bravely innovative reforms driven by the policy agenda in decarbonisation, decentralisation, and socially equitable taxation reform required to build enabling social capital and human capital.

7. Exports in Medicine & Healthcare

This section outlines suggestions for exports in medicine and healthcare education, training, products and services from the Highlands & Islands that extend the current reach of Scotland on the one hand and complement existing initiatives elsewhere in Scotland. It is a response to Sir Lewis Ritchie's report on the redesign of health services in Skye Lochalsh and South West Ross (SLDWR) which identifies a number of innovative features for improving health and social care in remote, rural and regional settings, including digital applications and the foundation of a **Centre of Excellence for Learning, Education and Training (CELET)**.

Consideration is given to the following:

³⁹ Richard Wagner: "Imagination creates reality."

- 7.1 *Fast-tracking Training in Distributed Ledger Technology and Blockchain Coding*
- 7.2 *Health & Well-being in the Highlands of Scotland*
- 7.3 *Distributed Ledger Technology Acceleration of Advances in Health Services and Genomics*
- 7.4 *DLT-Based Application to Delivering Ultra-Secure Personalised Healthcare*
- 7.5 *Simulating Blue Zones: Curative and Preventative Simulation in Healthcare*
- 7.6 *Anti-Aging Beyond Simulating Blue Zones*
- 7.7 *Destressing Medical Practitioners*
- 7.8 *DLT-Based Application to Assist in Coping with Depression and Suicide*
- 7.9 *DLT-Based Application in Adapting Healthcare to Climate Change*
- 7.10 *Health-Led Boosting of National Productivity*

7.1 Fast-tracking Training in Distributed Ledger Technology and Blockchain Coding

Since a great deal of the export potential outlined in the following is based on applications of Distributed Ledger Technologies (such as blockchain) we make the case for fast-tracking training in Distributed Ledger Technology (DLT) and blockchain coding. This article from [The Conversation](#) and reprinted in July 2018 Scientific American indicates Scotland is way behind in the application of DLT-Blockchain for healthcare, compared with Scandinavia and nigh on 6 years behind Estonia.

Perhaps the attractions of Skye would make HIALba-IDEA together with Sitekit and the Skye-based wing of the Digital Health Institute the ideal place for young Scottish IT graduates, devoid of DLT-blockchain coding experience to undertake 6-week and 6-month immersive courses. Portree-based Sitekit is well placed to host this training, especially through their alliance with MIT, the world's leading institution in training of DLT coding. Conceivably there is a significant cohort of Scottish high school youths (high on coding learning curves) who could go directly into this course. The Russian, [Vitalik Buterin](#), who developed [Ethereum](#) in 2013 was 19 at the time.

7.2 Health & Well-being in the Highlands of Scotland

Sir Lewis envisages a centre for excellence 'for multidisciplinary undergraduate and postgraduate training and learning' referred to as CELET being based in SLSWR. Such a centre could be an excellent way of attracting a range of clinicians to live and work in a rural setting and indeed perhaps address the issue of GP burnout that seems to be a feature of urban areas. International research confirms that local training provision encourages recruitment and retention of health care workers. Local GP practitioners on Skye report that many clinicians are already attracted to Skye for such local training, due to its iconic status, but they cannot really do this in a way that would create a real difference to the Highland economy. The Ritchie report envisages such a centre should 'foster future workforce capability for the remainder of NHSH and for other remote and rural areas throughout Scotland'.

A key stakeholder in this venture would be the [Remote and Rural Health Care Alliance \(RRHEAL\)](#) and [NHS Education for Scotland \(NES\)](#). Other relevant training partners include SAS, NHS24 Medical Schools and relevant academic partners. The University of Glasgow, for example, was recently involved in a two-day training course on Skye for GP's which was 'sold out' within minutes given its location. Additionally, the [University of Glasgow's innovative GP training programme](#) could be a useful link. Furthermore, and as the Ritchie report points out, the University of the Highland & Islands (UHI) already has ambitions for Remote and Rural Healthcare learning, teaching and research which could include the UHI college in Portree.

Additionally, lessons could be learnt from the experience in other countries and the [Centre for Rural Emergency Medicine](#) in Australia would seem an important link given its existing global network. CREM Director Dr Tim Baker, Chair of the Emergency Medicine Certificate and Diploma Committee of the Australasian College for Emergency Medicine, characterises their approach by saying that "Communities come up with great ideas to rural problems around the world. It is just tricky to know which community is succeeding in which area. I find that each small town has its own challenges and experts. Rather than provide direct advice, I usually try to let people know what others in similar situations have tried and what they have learned. Locals usually make the best decisions for locals if they are given adequate information."

Perhaps a lesson can be drawn from the Salford Royal Trust, the first NHS hospital to be rated outstanding twice. The Trust's chief executive (and an NHS chief executive) recently reasoned that the [NHS's plethora of](#)

[separately operated hospital fiefdoms](#) “are a key reason why standards in care vary so dramatically in what is meant to be a national health service”.

The incorporation of such best-practice advances into a means of communicating this throughout the Highlands and Islands with a view to overhauling the operation of the NHSH and the hospitals under its purview (as noted earlier, making use of AI-governed-machine-learning based on “desiloised” access to and drawing on analysis of “Big Data” holdings through highly secure Distributed Ledger Technology networks) could lead the way to an overhaul of the NHSS leading to advances in the development of software and enabling hardware that could be scaled to significant businesses such as Skye-based Sitekit, conceivably growing to the scale of global majors in this rapidly growing space.

7.3 Distributed Ledger Technology Acceleration of Advances in Health Services and Genomics

Distributed Ledger Technology (DLT) is providing opportunities to revolutionise health services by “de-siloising” operations for increased system efficiency and effectiveness while fulfilling the dream of enabling patients to access securely their own health records. This is being explored and tested by the UK National Health Service – [Can Blockchain save the NHS?](#) – largely based on progressive tech savvy doctors and the recommendations of the 2016 report of the UK Government Office for Science: [Distributed Ledger Technology: beyond block chain](#). In contradistinction the National Health Service of Scotland (NHSS) do not appear to be conducting similar assessments, if this 2018 IT-based assessment is valid: [Old IT and staff reluctance stop Scottish NHS from adopting new tech](#). At the leading edge of delivering core capacities stands MIT’s research project [MedRec](#) trialling a records system to manage the complexities (including secure patient access) of multi-institutional, lifetime medical records.

Epidemiological campaigns at national and international scales and attendant drug design, production and timely delivery also stand to benefit from advances in DLT: [Global Public Health: Blockchain for Contagious Disease Relief](#).

Central to the de-siloising advances in the worlds of medical research is 'Permissioned Blockchains' configured to control participant transactions, define their roles to access and contribute and to maintain their identity. Of even greater relevance is the capacity for participants to allow databases they control on a prescribed DLT platform operating in the public domain to be used for calculation and scenario simulation purposes whilst keeping the data private even in public networks, once again through an MIT-led advance - [SNARKs for C: Verifying Program Executions Succinctly and in Zero Knowledge](#). Given the availability of this capacity in the early 2000s, particularly DLT-enabled authentic IP ownership and hyper-secure protocols, it is likely that CRISPR as the leading advance in molecular cell engineering would be several years ahead of where it is today: in fact, by the time a panel of judges at the US Patent and Trademark Office gets around to deciding on patent ownership, CRISPR may have lost its preeminent title as the most precise tool for genetic engineering.

The SNARK enabled Blockchain as a Service (BaaS), specifically a scenario simulation service, has already been commercialised by the NASDAQ listed company [SimulationsPlus](#) with a market capital of \$367m. Of relevance here is the recent [“Large-scale investigation of the reasons why potentially important genes are ignored”](#). With research to date concentrating on about 2,000 of the 19,000 genes in the human genome, gene-specific strategies resulting from this investigation may assist in identifying significant but ignored genes thereby probing novel directions of investigation. Clearly, this could be accelerated by applying AI (algorithms derived from gene-specific strategies) to Big Data sets being generated from machine/deep learning probes at multiple investigation sites connected by SNARK-based BaaS-DLT. This could also accelerate the vast number of research efforts in stem cell research directed to the discovery of commercial drug treatments. For example, the award-winning Scottish company [Cytochroma](#)⁴⁰ confirms that “drug discovery is becoming more expensive and ineffective due to the lack of models and tests to predict toxicity”.

Now imagine that such a DLT-BaaS could be delivered by a company like Skye-based Sitekit⁴¹ (building on its strong alliance with MIT) in revitalising the IT support of NHSS as a forerunner to customising the end result for health services worldwide. Further imagine the HIAIba-IDEA think tank working in conjunction with Sitekit (sporting a growing number of world-class DLT blockchain-engineers and an alliance with the Skye-

⁴⁰ CEO & Founder of Cytochroma, Dr Kate Cameron won the 2018 Higgs EDGE prize of £150,000 for entrepreneurial businesses in science, technology and engineering, as adjudicated by prominent Scottish entrepreneurs.

⁴¹ Sitekit goal: for every person in the world to have secure access to innovative digital services that provide them with the right information, at the right time, using technology that’s familiar and easy-to-use.

based offshoot of DHI⁴²) and the University of Glasgow's Centre for Cell Engineering⁴³ collaborating in the establishment of first-to-market Scottish start-up companies (featuring many Unicorns?) resulting from DLT-accelerated advances in genomics, including breakthroughs in stem cell therapies.

7.4 DLT-Based Application to Delivering Ultra-Secure Personalised Healthcare

Effective access to comprehensive patient data through electronic health records (EHR) systems has had to deal with records fragmented across many healthcare stakeholders, often due to various providers using different EHR systems, attendant siloed data holdings and concerns with the heightened risk of security breaches by centralising these systems.

This paper "Blockchain in Healthcare: A Data-Centric Perspective" provides an account of the how the management of healthcare records can be greatly improved by applying three of the major strengths of distributed ledger technologies:

- Ultra-secure and immutable store of information
- Decentralization of transactions
- Built-in gamification

Descriptions are provided of the application of these strengths to areas of great promise that include:

- Personal Health Record (PHR)
- Population Health
- Personalised Medicine

Personal Health Record (PHR)

The PHR is seen as the key building block of the healthcare blockchain ecosystem with many efforts in existence to develop and popularize various versions since the early 2000's in the face of inadequate security protocols and interoperability problems curtailing its adoption. The paper details the ways in which DLT is well placed to overcome both these drawbacks and accelerate the transition to patient-centric healthcare by putting the patient and the patient's data at the centre of the healthcare ecosystem.

Population Health

Population health data is medical information that is specific to a particular demographic. Blockchain provides strong solutions for population health management facing challenges that include low data security, share-ability, and interoperability due to the siloing of patient information in insecure, non-compatible EHR systems which cannot easily exchange information. As a result, there is a scarcity of usable population health data sets across diverse patient populations.

The paper also provides a lucid account of blockchain technology can enable participants in population health studies to monetize their data.

Personalized Medicine

An account is also provided of how DLT-blockchain has the ability to make personalized medicine mainstream. Personalized medicine is tailored to an individual based on their health data including medical history and genetics. Because blockchain can facilitate ready access to a person's PHR and to relevant population health data, healthcare providers may soon provide routine individualized treatment.

Consider a future in which family doctors upload the results of using advanced scanning technology to diagnose heart failure problems with 100% accuracy instead of the reported 35% to 50% today without this equipment. Further consider CT and MRI scanning technology that is wearable allowing the family doctor to upload vital information on the condition of all of a patient's organs aided by AI-ML algorithms to produce 100% accurate diagnosis. In time this wearable technology could be of sufficiently low cost that patients at high risk could wear it away from the surgery and be connected online to their family doctor. According to this researcher this could

⁴² Digital Health Institute: Our vision is that innovation in digital health and care will help the Scottish population to live longer and healthier lives, while creating new jobs for the economy.

⁴³ The Centre for Cell Engineering (CCE) is a multidisciplinary, collaborative group of international standing working in tissue engineering. The group consists of biologists, bioengineers, clinicians, chemists and physicists.

be occurring in the next five years⁴⁴. Now add to this the information that is being ascertained from medical advances from genomics as considered in the previous section and we start to build data of immense value to the patient per se and possibly a financial return from releasing it to the population health data holding.

Other DLT Uses

Also noted there are other DLT uses for the healthcare industry include:

- Beneficial behaviour modification programs (fitness, diet, vice management)
- Medical products supply chain tracking
- Medication tracking and provenance
- Medical treatment audit trail
- Medical billing audit trail
- Patient consent management
- Virtual clinical trial management

Challenges = Opportunities

Given the early stage of DLT in healthcare, the fact that there are few successful case studies, slow transaction speeds, lack of scalability, and limited storage capacity and other challenges more healthcare related such as:

- Players are late adopters of technology
- Transition from paper to digital data still in process
- Ecosystem players not always willing to share information
- Medical data, especially images, are too large for current blockchain storage
- Data interoperability is in early stages across the industry
- Regulatory environment is cautious and slows progress

For Scotland these challenges provide opportunities to catch up and surpass, particularly if successful cases can be developed for entire healthcare systems such as NHS as a precursor to the NSHS and scaling this to the delivery of DLT-based software systems as a major export industry beyond healthcare services.

7.5 Simulating Blue Zones: Curative and Preventative Simulation in Healthcare

In the past few decades medical and healthcare simulation has been increasingly assisting in reducing and preventing deaths from medical errors - [Medication Errors Occur in 50% of Surgeries. Can Simulation Training Help?](#) To support remote and rural healthcare practitioners, NHSS has established the [Clinical Skills Managed Educational Network](#) (CS MEN) to improve “patient safety and clinical outcomes by supporting access to high quality, multi-professional skills training and clinical simulation across all geographical areas of Scotland. CS MEN develops online educational resources, manages and deploys a Mobile Skills Unit (MSU) which provides state of the art simulation facilities for remote and rural healthcare practitioners and has built a national network of healthcare educators and practitioners.”

It would seem that simulation-based healthcare education and training, particularly with a focus on delivering **community-determined** emergency medicine solutions, would be worth pursuing by the proposed **Centre of Excellence for Learning, Education and Training**.

Beyond this HIALba-IDEA proposes initiatives to develop forms of preventative simulation in healthcare influenced by the [Blue Zones Project: Learn how to transform your community to live longer, better](#). The Blue Zones refers to the five locations with the highest proportion of people reaching age 100: Barbagia in mountains of Sardinia; Ikaria, Greek Aegean Island; Nicya Peninsula, Costa Rica; Loma Linda, California, and Okinawa, Japan.

The selection criteria are listed below with a commentary on possible HIALba-IDEA simulation-based initiatives.

1. Move Naturally

⁴⁴ As noted in page 5, new technologies utilising light and sound to track tumours and measure neural activity may replace the CT and MRI scanners with a cheaper, more efficient and [wearable system](#).

The world's longest-lived people don't pump iron, run marathons or join gyms. Instead, they live in environments that constantly nudge them into moving without thinking about it. They grow gardens and don't have mechanical conveniences for house and yard work.

Response: HIAIba proposes all of life movement in the croft-based permaculture and afforest operations: "small communities of elderly citizens moving from acute hospital beds to community care and the therapy of participating in permaculture and afforest activities" (page 12).

2. Purpose

The Okinawans call it "Ikigai" and the Nicoyans call it "plan de vida;" for both it translates to "why I wake up in the morning." Knowing your sense of purpose is worth up to seven years of extra life expectancy.

Response:

Why not ask the sprightly why this is so for them and ask them to share their joie de vivre. We envisage croft hamlet life as described above (pages 12-13) and outlined below will increasingly enhance such outcomes for many.

3. Down Shift

Even people in the Blue Zones experience stress. Stress leads to chronic inflammation, associated with every major age-related disease. What the world's longest-lived people have that we don't are routines to shed that stress. Okinawans take a few moments each day to remember their ancestors, Ikarians take a nap and Sardinians do happy hour.

Response:

The various croft-based activities envisage hamlets emerging on many crofts offering diverse opportunities for life, work and play offering varied down shift opportunities.

4. 80% Rule

"Hara hachi bu" – the Okinawan, 2500-year old Confucian mantra said before meals reminds them to stop eating when their stomachs are 80 percent full. The 20% gap between not being hungry and feeling full could be the difference between losing weight or gaining it. People in the Blue Zones eat their smallest meal in the late afternoon or early evening and then they don't eat any more the rest of the day.

Response:

Perhaps croft hamlets could make some of the evening meals community based following this guideline along with a happy hour adhering to criteria 6.

5. Plant Slant

Beans, including fava, black, soy and lentils, are the cornerstone of most centenarian diets. Meat—mostly pork—is eaten on average only five times per month. Serving sizes are 3-4 oz., about the size of deck or cards.

Response: the Alba Vegan initiatives (page 10) offer superb diversity with some it stemming from croft-based permaculture/afforest produce, raw and processed locally in an eco-industrial park (pages 10-11).

6. Wine @ 5

People in all Blue Zones (except Adventists) drink alcohol moderately and regularly. Moderate drinkers outlive non-drinkers. The trick is to drink 1-2 glasses per day (preferably Sardinian Cannonau wine), with friends and/or with food. And no, you can't save up all weekend and have 14 drinks on Saturday.

Response: covered in criteria 4 response – perhaps with kelp beer and kelp caviar (pages 10-11).

7. Belong

All but five of the 263 centenarians we interviewed belonged to some faith-based community. Denomination doesn't seem to matter. Research shows that attending faith-based services four times per month will add 4-14 years of life expectancy.

Response: Many of the elderly of Skye practice this one. Perhaps croft hamlets will also find other ways such as beaming in laughter-rich entertainment one night per week.

8. Loved Ones First

Successful centenarians in the Blue Zones put their families first. This means keeping aging parents and grandparents nearby or in the home (It lowers disease and mortality rates of children in the home too.). They commit to a life partner (which can add up to 3 years of life expectancy) and invest in their children with time and love (They'll be more likely to care for you when the time comes).

Response: For those unable so to do, the advent of increasing advances in communications technology could help, especially as advances in holography and virtual reality go some of the way. The highly affordable home

building through 3D printing we envisage to support wide ranging activities in croft hamlets would also offer the prospects for family to visit and stop over regularly. (page 12).

9. Right Tribe

The world's longest lived people chose—or were born into—social circles that supported healthy behaviors, Okinawans created “moais”—groups of five friends that committed to each other for life. Research from the Framingham Studies shows that smoking, obesity, happiness, and even loneliness are contagious. So the social networks of long-lived people have favorably shaped their health behaviors.

Response: Perhaps the elderly would have a least one close friend co-located in the hamlet and others in nearby hamlets, villages and towns. Increasingly low cost of producing videos of Council meetings, Community organisation meetings, religious services, local GPs' regular messages, Emergency Services messages and so on could become commonplace for watching live or on catch up mode thereby helping to build and enhance a sense of community. It is also envisaged that hamlets could house one or more folk trained in providing day-to-day communicative support to the elderly. As society becomes more aware of the value to communities, and indeed the nation, of such contributions, remuneration will increasingly reflect this valuable service.

Much of the experiences gained from this initiative would be of intense interest in many international fora. Accordingly, a DLT network (similar to the forgoing) linking and involving communities-of-interest worldwide would put Scotland prominently on the global medical map in an increasingly significant field of interest.

7.6 Anti-Aging Beyond Simulating Blue Zones

A recent breakthrough in [“Reversing wrinkled skin and hair loss in mice by restoring mitochondrial function”](#) reported in *Nature* (July 2018) appears to be a significant advance in this field that is being pursued by many leading medical research institutes. In this case we envisage the advantages that could ensue by keeping abreast of this research effort and other research efforts, for example, the intense effort now in train to determine whether the above breakthrough or variations/extensions of it applies to all of the organs of the body. By keeping abreast we could offer a significant service in our proposal to establish a world-class International Highlands & Islands Hospital (IHIIH) operating fully equipped centres at each from the proposed 25 new towns.

In addition to providing the most advanced anti-aging treatments, the hospital could deliver patients highly nutritious cuisine choices prepared to at least Michelin 1-star level drawing on produce from local crofts and eco-industrial park (EIP) preparing meals using, among other things, sous vide, cook chill and other advanced preparation processes. From this base EIPs could coordinate to supply these meals to hospitals throughout the UK and Europe.

As patients reach recuperating stages in their treatment opportunities could be provided to allow them to have blue-zone, croft-based experiences, instructive visits to the local EIP, and organised tours of some of the world's most scenic landscapes. Wealthy international patients could be provided presentations on how to invest in local businesses including research business start-ups.

While this distributed hospital would meet the highest international standards, it would be available to locals through the NHS as well as international patients. Each distributed centre could grow as international patient demand grows such that there may be many more international patients than local patients, representing a significant export effort in world-class healthcare services.

A similar case could be made for the establishment of an international hospital in the South West.

7.7 Destressing Medical Practitioners

Perhaps the key characteristic of best practice hospitals and their networks of associated general and specialist medical practitioners is a cohort of doctors that are supported in maintaining and strengthening their initial reasons and passions for a career in medicine.

It is conjectured that worldwide the top 1-2% of school matriculants will gain entry to medical school with the top <1% for leading schools. Does this typically lead to a significant cohort of under-utilisation of a nation's intellectual horsepower? Are too many medical practitioners insufficiently challenged intellectually, unless they take the medical research pathway? Is this likely to intensify as auto-diagnosis proves superior to even the best of practitioners and specialists? Will this lead to increasing the prevalence of chronic stress -

Prevalence of chronic stress in general practitioners and practice assistants: Personal, practice and regional characteristics? – and burned out doctor's?

To existing countervailing strategies, we suggest adding the following activities designed to engage medical practitioners individually and in groups located anywhere on the planet through a secure distributed ledger technology (DLT) based network. Headlining this initiative could be the expression of vignettes on the history/emergence of medical based movements such as the heroic global reach of MSF, or the Flying Doctor Service in Australia, the near miraculous containment of potential pandemics (e.g. recent heroics in arresting spread of Ebola), and so on.

Suggested activities include how doctors individually and collectively:

- (1) achieve the near impossible against intransigent bureaucracies.
- (2) specify medical research initiatives - with all manner of success stories from the past.
- (3) build websites, online fora, etc to disseminate insights, again with successful examples/stories as a guide.
- (4) thrive in remote communities by communicating purposefully with peers (e.g. through initiatives like the [Centre for Rural Emergency Medicine](#)) and communicating with others by participating in all manner of communities-of-interest such as indicated in the next point...
- (5) disseminate/share interests in books, travel, wine, nutritious food, music, art, photography, etc, etc again with case studies on how this has already been done to a level of considerable effect: e.g. in nutrition by Dr Michael Gregor's [NutritionFacts](#).
- (6) start up non-medically-focussed charities and/or businesses (perhaps medical spin-off businesses) with examples of how this has been done by medical practitioners worldwide.
- (7) the tech savvy could participate in the sorts of initiatives outlined in Annex A: "Distributed Ledger Technology Acceleration of Advances in Health Services and Genomics".
- (8) create all manner of other opportunities bounded only by imagination.
- (9) contribute to crafting the myriad case studies, stories, vignettes noted in the foregoing.

A major endeavour with a potentially sky-high socio-economic return, possibly enabled by a WHO-sourced investment to HIAIba-IDEA operating in conjunction with Sitekit.

An export from Scotland delivering significant marketing glow for Scottish medicine.

7.8 DLT-Based Application to Assist in Coping with Depression and Suicide

Worldwide far too many suicides are the ultimate expression of depression.

As reported in [The Scotsman](#), there was 680 suicides last year in Scotland. A change of policy is now proposed to examine cases beyond those who had been in contact with health and social services to identify treatment mistakes to including the examination of cases where no apparent blame could be attributed. Strategies to reduce this by 20% by 2022 are focussed on widening opportunities to enhance access by sufferers to opening up to their friends, family and confidential helplines such as the Samaritans who hold the view that most "who feel suicidal do not actually want to die; they do not want to live the life they have" and while this may seem to be a small distinction it is critical "and why talking through other options at the right time is so vital".

With his mind are there emerging technologies than can help to cope with depression? Or better still simple interventions through conversing with machines deployed seamlessly, in real-time, well before an individual slides into depression? This article [How Cutting Edge Technology Can Help With Depression](#) answers these questions convincingly.

One outcome of such interventions could be the vast DLT-based accumulation of preventative cases histories, released by the consent of individuals, by remote, regional and city locations within nations that will become available for AI-based Big Data analysis. Among other things this will increasingly enhance the sophistication of machine-based conversing.

Once again does Scotland want to take an international lead in this direction and benefit from the attendant export potential?

7.9 DLT-Based Application in Adapting Healthcare to Climate Change

Dr George Crisp representing [Doctors for the Environment](#) in Australia states in this [interview](#) that "climate change has been recognised as the most significant threat to health in the 21st century by the WHO and Lancet". He also noted that the UK was 10 years ahead of Australia in adapting healthcare programs to existing and emerging climate change. Notwithstanding, the UK with a more equable climate than Australia, and likely to face less extreme change, is potentially facing an increase in heat-related deaths to about 7,000 per annum.

This represents an opportunity as well as a challenge. The more the UK and Scotland rise to the challenge the greater the opportunity.

Specifically, imagine a DLT-blockchain securely connecting and "desiloising" access to national climate change data bases and short-medium-long term weather forecasting together with national databases of healthcare adaptive responses (heat stress, epidemiological and so on) to possible scenarios (heat stress, epidemiological, storm-based isolation threats and so on) by zones (increasingly micro-climatically determined).

Now if Scotland sees the opportunity of developing AI & machine-learning algorithms and attendant Big Data analysis to implement this for Scotland as a prototype it could do so with a view to scaling this for the UK as a whole as a precursor to servicing Europe and the world, in collaboration with the WHO and the WMO. Opportunities could also encompass the manufacture of climate change adaptation technologies for widely varying situations worldwide.

7.10 Health-Led Boosting of National Productivity

This Times article on the health of Scots at home is disturbing: [Fighting Fat: The news on diet is grim — but Finland's approach offers hope](#)

One thought is to develop an ongoing national campaign that seeks to involve Scots actively in a health-led form of "economic patriotism" along the lines of this clumsily worded pitch:

Boost the Scottish economy and job prospects for your kids by eating healthily! Not only because a lesser national ill health bill means less drag on the national purse. But also because Scotland is well placed to grow several global-scale, healthy food companies if you have their backs by consuming their products and eating your own way to good health.

Among other things, could be the publication (newspapers, magazines, documentaries, social media videos, Ted Talks, YouTube videos, etc) of lively case study articles on, for example:

- (1) existing genuinely healthy food companies based in Scotland with exciting prospects of going global
- (2) emerging highly innovative and export-oriented companies; e.g. currently producing kelp caviar, kelp beer, vegan cheese, etc, etc (page 10-11)
- (3) prospects for seaweed-based food packaging (page 7)
- (4) our vegan export industry stories – see sky's the limit case made earlier (page 10)

And integrating this with [Finnish initiatives](#) that we think would resonate with salt/sugar/fat addicted Scots.

Of course, the boost to the economy by supercharging health food companies even to the scale of several global majors would be orders of magnitude less significant than the boost to national productivity that would flow from Scots actively and informatively caring for their own health through the food they consume.

8. Exports in Education & Training

Is it possible to boost education exports in a way that delivers markedly better educational outcomes for Scots resident in the Highland and Islands (HI)? Does it stretch credulity that 20,000 crofts could host 100,000 overseas students with high leadership potential from developing countries? Could such hosting also lead to

beneficial educational outcomes for 100,000 HI Scots, more than an order of magnitude greater than the current student body of the University of the Highlands and Islands (UHI), with the increased intake of regional and foreign students resulting in an increase of up to 85% in the student body of Scotland? Could taxation reforms (see page 5 re land tax reform) facilitate free tertiary education for HI Scots with the developing country students funded from development assistance sources?

And why not a UHI campus at each of the proposed 25 new town as they reach residential populations of 5,000 to 10,000? Can we envisage a mighty distributed university with a student body of 200,000⁴⁵ with distributed ledger technology (DLT) systems designed to maximise the allocation of resource to teaching and research at each campus? Can we extend the DLT network to access free high-quality courses being developed for interactive e-learning and to contribute to the growing store of such free courses? Examples include the 2,400 online undergraduate and post-grad courses from MIT's *OpenCourseWare*⁴⁶ with [inspirational stories from Students, Educators and Self-Learners](#) and [WooTube](#) an award winning series of videos on high school certificate courses in mathematics and information technology⁴⁷ for students and teachers posted to YouTube. No prizes for guessing that of the top 10 or so MIT undergraduate courses most visited recently four were computer based – introductory courses in [Computer Science and Programming, Algorithms, Artificial Intelligence](#), and [Computational Thinking and Data Science](#) – together with a course on [Principles of Microeconomics](#). In addition to these and other high-quality learning resources that could be DLT connected, consider also the prospect of mining YouTube, Vimeo and other video sources for all manner of the highest quality, instruction-based, subject matter in language and literature, all of the social, physical and engineering sciences, playing musical instruments, all forms of artistic expression, dance steps, play acting, photography, cuisine preparations and so on all supported by AI-machine learning-Big Data analysis organising this in all manner of accessible ways into a truly “do-no evil” global learning corporate.

In the last section we traversed many opportunities in exporting IT based health services and technologies concluding with the urgent need to conduct courses in DLT such as those [MIT is providing on a commercial basis](#). The reader of this overview will note references to DLT support for accounting and communications within communities seeking to go off grid in energy and water supply, between crofting communities and nearby eco-industrial parks in the provision of goods and services, and between eco-industrial parks cooperating to meet large export contracts. This leads to the conclusion that the development of these DLT based services and attendant AI and machine learning could put Scotland in the vanguard of these forms of information and communications technologies with the prospects of scaling up from start-ups, to Unicorns⁴⁸ to major companies in this space.

As posited in Paper 9, achieving the growth of 25 new town settlements in crofting community heartlands, each averaging 10,000 residents, would throw a light of increased feasibility on the above questions of education export scale. In Paper 6 - a) page 13 - we envisage the education and training of overseas students in a wide range of on-croft intensive food growth activities, housed in low-cost, high-quality, utility-free, globally-connected 3d housing for one or two students. In many cases this training could proceed in tandem with local students possibly from the family of the host croft, or other crofting families in the community or the nearby new town.

In Paper 7 we suggest assessing the feasibility of establishing a new town, eco-industrial park (see Paper 5) and local communities of crofts catalysing these outcomes (Paper 6), entering the realm of possibility of replicating 25 times (and assessing the benefits of this Paper 8) if we can deliver a massive flow of FDI in renewable energy generation (Paper 4).

In the case of Portree and Skye, through HIAIba-IDEA, we have proposed elsewhere numerous collaborative R&D activities with a number of universities, based on advancing many of the proposals outlined in this Overview Paper. It is envisaged that similar opportunities would be pursued by the emergence of all new

⁴⁵ Sounds massive but still only a tenth of the [largest student bodies in the world](#).

⁴⁶ *Unlocking Knowledge*: MIT OpenCourseWare (OCW) is a web-based publication of virtually all MIT course content. OCW is open and available to the world and is a permanent MIT activity. *Empowering Minds*: Through OCW, educators improve courses and curricula, making their schools more effective; students find additional resources to help them succeed; and independent learners enrich their lives and use the content to tackle some of our world's most difficult challenges, including sustainable development, climate change, and cancer eradication.

⁴⁷ Information technology courses include: [Decision Support Systems, Communications, Databases, Multimedia, Assorted IPT Videos](#)

⁴⁸ After all the Unicorn has been a Scottish heraldic symbol since the 12th century, befitting a country famed for its love for and long history of myth and legend.

towns, thereby opening up hundreds of opportunities for national and international graduate and post-graduate students in each new town, largely housed on and in part achieving learning and research outcomes from crofts.

We envisage that myriad opportunities will arise from on-croft applications of permaculture (vegan and non-vegan), afforestation, and hemp cropping for a burgeoning range of so-called superfoods, hempcrete for 3d housing (Paper 6(a), Page 13) to extend greatly the variety of foods currently grown on crofts for on-croft consumption as well as distribution to the local eco-industrial park for a wide range of export products boosted and underscored by a wide range of prospects for the innovative use of seaweed as well as hemp for food, packaging, building materials and advanced materials (Paper 5).

And what of the education and training exports from other 3 EU categorised regions of Scotland (pages 15-16)? Clearly the South West Scotland (SWS) region would have similar remote, rural and regional strengths to the HI region and, given renewable energy generation from wave and tidal resources on the scale proposed for the HI from wind resources, would be well placed to emulate and indeed co-develop with HI similar levels of educational and training exports to developing countries, perhaps through another distributed capacity centred on the University of the West of Scotland (already operating from intraregional campuses in Ayr, Dumfries, Lanarkshire, and Paisley).

Such HI and SWS education and training export outcomes would be a 400% increase on the existing 50,000 per annum international students from more than 180 different countries study, primarily in the Eastern Scotland (ES) and the North Eastern Scotland (NES) regions. Just as clearly, however, ES and NES would not remain at this level. Commensurate increases in these regions would elevate Scotland to one of the main education exporting countries in the world and conceivably the highest ranking as a percentage of the enrolments of our tertiary education institutions.

Imagine the greatly enhanced export outcomes in general that would flow from our relationships with educating and training students with leadership potential on this scale from developing countries. Or indeed, thinking on a higher plane of socio-economic-environmental advancement, the major contributions to building social capital and human capital from our own young people that could flow from the blossoming of lifelong relationships with their developing country “compatriots”, particularly if we make it possible for our students to conduct part of their education and training in the field with these “compatriots” in their own countries.

9. Why Scotland?

Why should Scotland take a leading role in ensuring the benevolence of AI?

Leadership already is taking form through the operation and establishment of entities such as the following:

- **Academe** – Adam Smith to Herbert Simon; Karl Marx to Paul Krugman; MIT dualists Noam Chomsky and Marvin Minsky.
- [Association for the Advancement of Artificial Intelligence](#) (AAAI) - founded in 1979 as a non-profit scientific society devoted to advancing the scientific understanding of the mechanisms underlying thought and intelligent behaviour and their embodiment in machines by promoting: (a) AI research and its responsible application; (b) increased public understanding of AI; (c) improving the teaching and training of AI practitioners; and (d) providing guidance for research planners and funders concerning the importance and potential of current AI developments and future directions.
- [OpenAI](#): Discovering and enacting the path to safe artificial general intelligence by ensuring that AI discoveries are publicly available and preventing private companies from doing evil. Established in 2015 by Elon Musk based on the prospects of an “existential threat from machine superintelligence” with [support expressed by Bill Gates and Stephen Hawking](#).
- Following Musk’s imperative “[We need to regulate AI before ‘it’s too late’](#)” is a recent proposal under the auspices of the AAAI to create a unified framework for the regulation of AI technologies and inform the development of AI policies around the world by means of an [International Artificial Intelligence Organisation](#) to assess the impact on international trade, politics and war of existing developments and

their evolution that include cryptocurrencies, personalized political ad hacking, autonomous vehicles and autonomous weaponized agents.

- **GDPR:** The [EU General Data Protection Regulation](#) “is the most important change in data privacy in 20 years, fundamentally reshaping the way in which data is handled across every sector, from healthcare to banking and beyond”; UK Information Commissioner’s Office – [Big Data, artificial intelligence, machine learning and data protection](#).
- **Ethical AI:** A concerted effort is being made by the Boston/Istanbul based [AI Ethics Lab](#): “Our goal is to enhance technology development by integrating ethics from the earliest stages of design and development for the mutual benefit of industry and communities. Our work aims to provide ethics guidance to researchers, developers, and legislators.”
- [AI in the UK: ready willing and able?](#): report by the *House of Lords Select Committee on AI* which makes the case that “the UK is in a strong position to be a world leader in the development of AI”, particularly by putting “ethics at the centre of AI’s development and use”.
- [The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems](#): Institute for Electrical and Electronics Engineers: An incubation space for new standards and solutions, certifications and codes of conduct, and consensus building for ethical implementation of intelligent technologies.
- [Montréal Declaration for Responsible Development of AI](#): Drafted based on consulting with individuals on the internet and in bookstores, gathering opinions across disciplines – including philosophers, sociologists, jurists and AI researchers. Declaration can be signed [here](#).
- [Future of Life Institute](#): Currently focusing on keeping AI beneficial and exploring ways of reducing risks from nuclear weapons and biotechnology. Based in Boston area, and welcomes the participation of scientists, students, philanthropists, and others worldwide – [video](#) highlighting activities.

Our proposal is to conduct a global annual forum in Scotland in collaboration with the Singularity University Summit process to assess and foster progress in “benevolating” AI. We focus on the contributions of AI to build social capital with governments, existing enterprises and startups in delivering global equity in education, health, shelter, employment, belonging and how the resulting outcomes could “benevolate” AI.

Scotland’s is well-placed to host such an annual global summit given “game changing” contributions to the advancement of science, technology and engineering that includes:

*classical economics – steam engines – thermodynamics (latent heat) – temperature measurement
logarithms & computation – electromagnetism – electric vehicles⁴⁹ – bicycles – sealed roads – tyres
water-proof fabrics – telephony – television – radar – antibiotics (penicillin) – stem cells
gravitational wave detection – boson particle physics – wave & tidal energy
[kite-generated electricity](#) – LiFi-IoT⁵⁰ – potentially in battery technology⁵¹.*

9.1 AI and Classical Economics

The Economist (August, 2018) reporting on “[How Adam Smith predicted the power of Big Tech](#)” and noting Smiths’ highly elaborated concerns in the *Wealth of Nations* (WN) about the rise of corporate power, oligopoly and monopoly, finds an echo in a recent [IMF report](#) lamenting the marked rise in the “economic wealth and power” of corporations in Big Tech, airlines, pharmaceuticals, and auditing. Of primary concern is that the significant increases in mark-ups averaging 43% in advanced economies since the 1980s have been trending higher in the past decade, mostly driven by Big Tech – principally the FAANGs (Facebook, Apple, Amazon, Netflix, Google).

⁴⁹ Robert Anderson was a 19th-century Scottish inventor, best known for inventing the first crude electric carriage in Scotland around the time of 1832–1839. The carriage was powered by non-rechargeable primary power cells.

⁵⁰ The Li-Fi R&D Centre is located within the Alexander Graham Bell building, University of Edinburgh. LiFi (Light-Fidelity) is high speed wireless communications through light emitting diodes which is enabling advances in connecting and controlling the Internet of Things (IoT) – the network of devices such as vehicles, and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data.

⁵¹ Jia-Jia Chen, Mark D. Symes & Leroy Cronin, *Nature Chemistry* **10**, 1042–1047, Highly reduced and protonated aqueous solutions of [P₂W₁₈O₆₂]⁶⁻ for on-demand hydrogen generation and energy storage. See also *Smart Energy International* (Dec 2018) [Hybrid Energy Storage: University of Glasgow](#).

If the WN anticipates the pre-eminence of Big Tech then the *Theory of Moral Sentiments* (TMS) provides a potentially profound contribution to achieving the benevolence of AI as the driver of this pre-eminence – even maximising the wellbeing of humans and the global environment.

Writing in *The Economist* (November 2018), Jonnie Penn of the University of Cambridge paraphrases Nobel economist Herbert Simon in his title [“AI thinks like a corporation – and that’s worrying”](#): AI was born of organisational decision-making and state power; it needs human ethics.” Simon as a coinventor of the virtual machine the [Logic Theorist](#), heralded as the first working AI prototype, identified Frederick Taylor, the father of the scientific management movement, and [Charles Babbage](#), originator of the concept of a digital programming computer, as intellectual predecessors, and that “Physicists and electrical engineers had little to do with the invention of the digital computer”. Penn then reports that Simon infers:

“The real inventor was the economist Adam Smith”. He explained the connections that [Gaspard de Prony](#), a French civil engineer, set out to “manufacture” logarithms⁵² using techniques drawn from WN. Babbage, inspired by Prony, converted this insight into mechanical hardware. In the mid-1950s, Simon transmuted it into software code.

If, as Simon deduces, Smith played a role in the process of inventing the digital computer, then as noted above, TMS, especially the concluding Part VII: Systems of Moral Philosophy, provides a process that could contribute to reaching agreement on human ethics for the governance of corporations and agencies of states exploiting AI advances in the exponential advancement of their businesses and administrations.

More recently there has been a slew of articles on the role of Smith’s “invisible hand” in the laissez faire operation of markets in which the bottom-up, substantially unregulated, emergence of advances in AI technologies in the west is compared with the top-down, state-governed aspirations of China’s national plan to achieve global leadership in AI: [“Is Xi Jinping’s iron grip better than Adam Smith’s invisible hand for technological innovation?”](#) reports the *South China Morning Post* (January 2019).

Earlier the *Washington Post* (May 2018) reported that “AI will spell the end of capitalism”:

“The most momentous challenge facing socio-economic systems today is the arrival of artificial intelligence. If AI remains under the control of market forces, it will inexorably result in a super-rich oligopoly of data billionaires who reap the wealth created by robots that displace human labor, leaving massive unemployment in their wake.

But China’s socialist market economy could provide a solution to this. If AI rationally allocates resources through big data analysis, and if robust feedback loops can supplant the imperfections of “the invisible hand” while fairly sharing the vast wealth it creates, a planned economy that actually works could at last be achievable.

The more AI advances into a general-purpose technology that permeates every corner of life, the less sense it makes to allow it to remain in private hands that serve the interests of the few instead of the many. More than anything else, the inevitability of mass unemployment and the demand for universal welfare will drive the idea of socializing or nationalizing AI.”

In reporting [“Artificial Intelligence must avoid a backlash”](#), the *Financial Times* (September 2018) expresses the view that “AI is the ultimate invisible hand”, one that is already at work in almost every aspect of our lives.”

What the foregoing and much of economics in general misinterpret is the role of Smith’s “invisible hand”, referred to only once in WN and once in TMS. In WN, Smith, notwithstanding his pre-capitalist support of free market systems and small government, provides an enlightened and nuanced case against what is now referred to as neoliberal globalisation. In effect he argues that merchants and manufacturers while aware of the benefits to themselves of offshoring production of goods to cheaper labour markets would know that this would have deleterious impacts on labour at home and as such as if by an “invisible hand” they probably would not do so. In the case of TMS, the usage provides a case for equality in an essentially agrarian society. Smith

⁵² John Napier (1614), Scottish mathematician and theological writer who originated the concept of logarithms as a mathematical device to aid in calculations.

provides the example that if a landowner accumulated very large land holdings on which people were dependent then just as by his natural sympathy for the welfare of others he would distribute the wealth so that it would end up with all concerned being relatively equal as if by an “invisible hand”. These interpretations, made a few years ago in this video by [Noam Chomsky](#) (linguistic scholar, cognitive scientist, philosopher and social critic) reinforce the foregoing proposal to return to the philosophical basis and underpinning moral sentiments of classical economics in the role that it can play in benevolating AI.

It accentuates the case for the application of AI to assessing the contribution of TMS to benevolating AI. Of relevance to such an endeavour is the recent pathbreaking [partnership of AI companies](#) to create a Knowledge Graph of the gargantuan body of writings of Chomsky, thereby turning the linked information into a searchable and retrievable resource for the public. Knowledge graphs capture facts related to people, processes, applications, data and things, and the relationships among them. Also promising is the application of animation to widen community involvement in public discourse in fundamental debates such as provided over 30 years ago by Chomsky in *Manufacturing Consent* in which he argues that the media creates the illusion of democracy. With over 1 million views the recent video [The Five Filters of the Mass Media](#) is revitalising interest in Chomsky and Herman’s surgical analysis of the ways corporate mass media “manufactures consent” for a status quo the majority of people do not actually want. Perhaps similar animation of TMS would lead to its wider comprehension and appreciation, including an appraisal of its contribution to benevolating AI.

Similarly relevant, MIT Technology Review (June 2018) considered a “[A digital capitalism Marx might enjoy](#)”, noting that while the conflict between labour and capitalism has shifted in favour of the latter, there are ways in which the former could contribute to achieving much fairer outcomes for all. One suggested way is for governments to take ownership in firms through major sovereign wealth funds buying

“shares on behalf of the data-generating public. Dividend payments would enrich the fund, which could in turn pay dividends to the public: the just reward for their contribution to production.”

Indeed, this has been practiced for several years by Norway contributing significantly to an extraordinarily generous welfare state. On the other hand, unbridled private ownership of “digital capitalism” will accelerate regression to oligarchic states and in the case of the USA “the very system our founders revolted against” as stressed by Paul Krugman in the video “[What the 1% Don’t Want Us to Know](#)”.

9.2 AI and Democracy: Reducing Inequality

A great deal has been written about the decline of democracy in the West that is attributed to the meta-strategy of most governments: privatising profits (primarily for the 1%) and socialising losses exacerbating the general decline in wages and employment conditions for the past 50 years, encompassing the middle class as well as the least provided. Politicians seeking to redress such imbalances include Corbyn in the UK, Sanders in the USA and Varoufakis in Europe. In attempts to “[democratise AI](#)”, the [Democracy in Europe Movement 2025](#) (DiEM25) has extended the Big Tech tax reform focus of Corbyn⁵³ to one that eschews proposals for a tax-funded Universal Basic Income (UBI), preferring a Jobs Guarantee program providing a path to full employment, similar to but not invoking Modern Monetary Theory (MMT) as per the earlier referred writings of Kelton who advises the Sanders’ political campaigns for President of the USA. In fact, [Bill Mitchell](#), the leading exponent of MMT reasons that UBI is a coercive, highly problematic and a neo-liberal strategy for serfdom without the work, particularly as there is increasing support among the elite of the 1%, but considers DiEM25 as a futile endeavour pointing out in a [recent article](#) that

“Nothing has changed since 1977 when the [MacDougall Report](#) concluded that the cultural and national differences between the (then) Member States of the European Communities were too great to allow an effective monetary union to be created. That assessment and the earlier work of Pierre Werner in his 1970 Report were ignored as the neoliberals in France and Germany rushed headlong to Maastricht.”

In addition to a Jobs Guarantee program, Varoufakis proposed a Universal Dividend (UBD) as an alternative to the UBI at the London Launch of DiEM25 UK:

“Varoufakis pointed out that one of the greatest fallacies of capitalism and of free market ideology is that wealth is created individually and then appropriated through the tax system by the state. The reality is, he noted, exactly the opposite — wealth is created collectively and then privatised. Since

⁵³ [Corbyn's Plans To Tax Tech Just Don't Go Far Enough](#), (Forbes Aug 2108)

capital is produced socially it should be enjoyed socially. In the light of this Varoufakis told the meeting that DiEM25 has been developing a policy, not of a Universal Basic Income, but of a Universal Basic Dividend. This would not be funded by taxation but through a Trust Fund into which a percentage of the shares of every corporation is to go, where the dividends amass, and which are then distributed to all as a Universal Basic Dividend. In Varoufakis' opinion this is the only way to share the returns of automation across society."

The UBD accords with the dividend suggestion made in the above article from the MIT Technology Review.

9.3 AI Thought Leaders

And what of the debate on AI and the technological singularity – when artificial general intelligence supposedly surpasses human intelligence and exponentially increases the gap between the two – where we have diametrically opposed reasoning from MIT intellectual titans Chomsky and Minsky? Chomsky takes the view that ["the singularity is science fiction"](#) and quips that for the past sixty years at MIT that he has been exposed to leading [AI researchers continuously claiming that it's in the foreseeable future](#). In a 2016 interview with [Ray Kurzweil](#), Minsky responds to the question of whether the singularity is near, "Yes, depending on what you mean by 'near'...It may well be within our lifetimes." Around the same time Minsky is recorded as saying that [Chomsky's theories of language were irrelevant](#).

As a cognitive scientist credited with remodelling the scientific study of language, Chomsky has sought to extend his early reasoning on (a) the innate nature of the linguistic capacity of humans (not acquired gradually through natural selection in the evolution of syntax, but rather due to a rewiring of the brain caused by a chance mutation⁵⁴) and (b) the development of the interplay between rules of language and the mind in efforts to (c) understand the mechanisms that the brain uses to create these rules. He comes from a point of profound comprehension to reason that we are nowhere near understanding the interplay between the preconscious mind (comprising, inter alia, memories, values, beliefs, emotions, sentiments – moral and otherwise) and the conscious mind and hence there is little prospect of AI bridging this gap in the foreseeable future. Notwithstanding, in responding to the question of whether he believes the mind to be computable Chomsky is in accord with the view that the mind is ["a computing machine or some sort"](#).

As the cofounder in 1959 of the MIT Computer Science and AI Lab, Minsky earlier built the first neural network machine, pioneered the analysis of neural networks, and created a framework for representing knowledge leading to a new paradigm in computer programming. His major contribution was the construction of a model of human intelligence systematically built up from the interactions between a vast "society" of simple "mindless" processes, referred to as agents, constituting what he called a [society of mind](#). In espousing a philosophy that "minds are what brains do" he responds to his own query "What magical trick makes us intelligent?" with "The trick is there is no trick. The power of intelligence stems from our vast diversity, not from any single, perfect principle." Minsky considers that the ["brain is 400 different computers"](#) and in modelling and building a brain "You can't do it from the bottom up."

Perhaps the application of Knowledge Graphs and attendant AI could be used to "mine" new insights from the collective works of Chomsky and Minsky related to language, brain, mind and AI. Alongside this, insights for benevolating AI may be derived from applying Knowledge Graphs to probe collectively TMS and Chomsky's prodigious output as a social critic – including his writings, burgeoning video-based commentary and a legendary online body of responses to queries from individuals.

Can insights also be generated by monitoring and analysing the online dialogue of AI thought leaders? In this insightful contribution ["Big tech company social capital among AI thought leaders: Who's up and who's down in the past year"](#), we are informed that [Andrew Ng](#), who claims "AI is the new electricity", is the AI thought leader most followed by AI industry leaders, leading to the query:

"If AI is going to become as fundamental and valuable as electricity, how are the big tech incumbents faring in the emergence of this radical new source of power?"

The article provides "a social network analysis of the artificial intelligence thought leadership space online and a measure of the social capital of eight big brands inside that space. Which companies is the AI industry paying attention to?"

⁵⁴ Chomsky N. (2010) 'Some Simple Evo devo Theses: How True Might They be for Language?' In: Larson R. K. et al. (eds) *The Evolution of Human Language*, pp. 45–62. Cambridge: Cambridge University Press.

9.4 AI and Ethics

Several notes on morals and ethics concerning existing, emerging and possible future advances in AI are provided earlier in this section and other sections of this Overview.

Many notable contributions to the consideration of AI and ethics have been produced by the [Future of Life Institute](#). Views and initiatives include:

[The Ethical Questions Behind Artificial Intelligence](#)

[Insight From the Dalai Lama Applied to AI Ethics](#)

[How Do We Align Artificial Intelligence with Human Values?](#)

[Towards a Code of Ethics in Artificial Intelligence with Paula Boddington](#)

[Podcast: Law and Ethics of Artificial Intelligence](#)

[Friendly AI: Aligning Goals](#)

[Developing Ethical Priorities for Neurotechnologies and AI](#)

[Research for Beneficial Artificial Intelligence](#)

[AI Should Provide a Shared Benefit for as Many People as Possible](#)

[Podcast: Mission AI - Giving a Global Voice to the AI Discussion with Charlie Oliver and Randi Williams](#)

[How to Prepare for the Malicious Use of AI](#)

[Governing AI: An Inside Look at the Quest to Ensure AI Benefits Humanity](#)

[Podcast: Artificial Intelligence - Global Governance, National Policy, and Public Trust with Allan Dafoe and Jessica Cussins](#)

[Podcast: AI and Nuclear Weapons - Trust, Accidents, and New Risks with Paul Scharre and Mike Horowitz](#)

...and a series of podcasts aligning AI with human values and weighing many and varied ethical issues involved in creating beneficial artificial intelligence:

[Podcast: AI and the Value Alignment Problem with Meia Chita-Tegmark and Lucas Perry](#)

[AI Alignment Podcast: Inverse Reinforcement Learning and Inferring Human Preferences with Dylan Hadfield-Menell](#)

[Alignment Podcast: Astronomical Future Suffering and Superintelligence with Kaj Sotala](#)

[AI Alignment Podcast: AI Safety, Possible Minds, and Simulated Worlds with Roman Yampolskiy](#)

[AI Alignment Podcast: The Metaethics of Joy, Suffering, and Artificial Intelligence with Brian Tomasik and David Pearce](#)

[AI Alignment Podcast: Moral Uncertainty and the Path to AI Alignment with William MacAskill](#)

[AI Alignment Podcast: On Becoming a Moral Realist with Peter Singer](#)

[AI Alignment Podcast: Inverse Reinforcement Learning and the State of AI Alignment with Rohin Shah](#)

[AI Alignment Podcast: Cooperative Inverse Reinforcement Learning with Dylan Hadfield-Menell \(Beneficial AGI 2019\)](#)

[AI Alignment Podcast: The Byzantine Generals' Problem, Poisoning, and Distributed Machine Learning with El Mahdi El Mhamdi \(Beneficial AGI 2019\)](#)

Compelling insights are provided by Divya Chandra (Harvard trained physician and neuroscientist) and Vivienne Ming quizzed together in this [Exponential Ethics](#) video from the recent SU Summit in Portugal.

This McKinsey podcast [The ethics of artificial intelligence](#) talks about how companies can ethically deploy AI, followed by a McKinsey series of six videos with transcripts on [AI for social good](#), and a McKinsey report from Davos 2019 on how AI is [Top of Mind](#).

9.5 Trust as a Preeminent Social Capital Resource for Benevolent AI

Early in this Overview we covered the importance of building trust as a social capital resource. Without trust there is little likelihood of the Harvard Negotiation Project's "getting to yes"⁵⁵ in the myriad negotiations envisaged in developing processes to use AI in building social capital and how increasingly strengthening social

⁵⁵ *Getting to Yes: Negotiating Agreement Without Giving In* is a best-selling 1981 non-fiction book by Roger Fisher and William L. Ury. Editions in 1991 and 2011 added Bruce Patton as co-author, all members of the Harvard Negotiation Project.

capital will reinforce the development of processes to benevolate AI. In the view of Francis Frie of the Harvard Business School, “trust is the foundation of everything we do”. In a widely viewed [TED Talk](#) she depicts trust as three sides of a triangle linking authenticity, logic and empathy. A wobble in any one threatens trust.



According to Frie achieving trust among all stakeholders in negotiations can lead to “unprecedented human progress”. Achieving authenticity can be the most vexing because “we as human beings can determine in an instant whether or not someone is being authentic with us.” So, the challenge in the negotiation processes is to establish conditions which fosters the contributions of stakeholders as their “authentic selves”. Achieving empathy can be the wobblest because of a common disbelief that many will doubt that others with all their distractions are in it for them. Identifying where, when, and to whom distractions are likely to be offered should trace to where, when, and with whom empathy is likely to be withheld. Logic wobbles can occur if either the quality of the logic is at risk or the ability to communicate it is lacking.

In [Who Can You Trust?](#) Racchel Botsman relates to what we all know and experience:

“From government to business, banks to media, trust in institutions is at an all-time low. Widespread corruption, elitism and economic disparity have led to a worldwide upsurge of anti-establishment movements.”

Conceivable this has led to the emergence and increasing acceptance of the sharing economy such as AirBnB, Uber and peer-to-peer exchange cryptocurrency largely transacted with strangers.

Many are moving from institutional enterprises characterised as –

Opaque — Closed — Centralised — Licensed — Top-down

to distributed network enterprises respectively characterised as –

Transparent — Inclusive — Decentralised — Accountable — Bottom-up.

We have touched on many cases in this report on possible applications in which blockchain and distributed ledger technologies (DLTs) may enhance and strengthen this movement. In asking “[Why Decentralised Technology Matters for Freedom](#)”, Alex Goldstein quotes [David Chaum](#): “The difference between a bad electronic cash system and a well-developed digital cash will determine whether we have a dictatorship or a real democracy.”

The orientation to dictatorship is characterised by the prevalence of enterprise DLTs that are

Closed — Centralised — Permissioned — Censorable

in contrast to democracy enhancing DLT networks, such as the Blockchain-based Bitcoin, that are

Open — Decentralised — Permissionless — Censorship-Resistant.

Accordingly, we propose to assess how the foregoing trust-building approaches can be applied to enhancing progress towards trustful AI-social-capital processes.

Achieving authenticity could flow from our proposed global forum in collaboration with the Singularity University Summit process to assess and foster progress in “benevolating” AI. Achieving empathy among stakeholders representing different cultures will be challenging. In this regard our earlier proposals for interdiaspora initiatives could support the required cultural learning. Earlier in considering “the four must haves of innovation” we noted culture as a driver in innovation. The quality of logic will depend on the validity of what we are proposing here.

And what of fake news? Fortuitously there are many algorithms to detect fake news ranging from the simple quick-and-ready DIY to the more advanced, some of which have been reviewed by IEEE: [Evaluating machine learning algorithms for fake news detection](#). And more recently a [mathematical paper on assessing the impact of fake news](#) is reviewed by MIT: [A mathematical model captures the political impact of fake news](#).

In sum, trust as a social capital resource enables change and innovation. As reasoned at the outset of this Overview, we perceive the need for innovation in building social capital given if it is to become a driving force in achieving and mobilising the quality of human capital to maximise well-being.

Turning now from this brief overview of how studies of contributions of thinkers past and present may be synthesised into approaches to benevolate AI, we consider the contributions that AI may make to building social capital in collaborations with governments, existing enterprises and startups to deliver global equity in education, health, shelter, employment, belonging and how the resulting outcomes could in turn reinforce the development of processes to benevolate AI.

9.6 AI in Education Social Capital

Academic research on AI in education is supported by the journal [The International Journal of Artificial Intelligence in Education](#) (IJAIED), the official journal of the International AIED Society focussed on the application of artificial intelligence techniques and concepts to the design of systems to support learning. IJAIED: (a) spans several fields of research and the interplay between them offering a broad spectrum of topics; (b) considers the application complex methodologies intrinsically related to education; (c) provides an international perspective of principles used for the design of computer-based learning systems.

There is a growing fear that next generation advances in AI for education will exacerbate inequality and disproportionately advantage the elite of the 1%. What about providing the elite with the earliest access to advances in neuroprosthetics currently focussed on overcoming disabilities such as deafness, blindness and spinal cord injury to advances in brain-computer interfaces (BCI) facilitating accelerated learning? Will this lead to invidious increases in inequality, assuming by then the existence of unhackable BCIs? Existing software for existing devices to overcome learning deficiencies provides a pathway to BCI algorithmic expression of emerging accelerated learning techniques and processes. We need to deal with this before it's too late. Scotland as an active player in BCI and brain sensor technology, including hosting and participating in [IEEE Brain events](#)⁵⁶, is well placed to contribute with distinction to this quest. Perhaps the most seminal contributions can be made in early education. Starting with pre-schoolers the [Think Equal](#) initiative is "empowering change through education" with the Mission:

"THINK EQUAL calls for a system change in education to end the discriminatory mind set and cycle of violence across our world. We believe there is a missing subject in school curricula. We ask governments to adopt our curriculum and its tangible tools mediating all aspects of experiential social and emotional learning. We ask them to mandate this as a new subject onto the compulsory curriculum of world schools from the earliest years when, according to neuroscientists, the child is cognitively modifiable."

Paraphrasing Aristotle, "Education of the head without education of the heart is no education at all", *Think Equal* exhorts: "We must ensure that our children's hearts are educated, and not just their heads."

"THINK EQUAL is a global initiative which constructs and delivers an equality studies curriculum, that is as fundamental as literacy and numeracy. We must commit to a holistic approach to education which will result in a new generation of equal thinkers - global citizens - who can rise to the challenges of the 21st century."

In this respect we can draw also on the field of cultural learning:

"Cultural learning, also called cultural transmission, is the way a group of people or animals within a society or culture tend to learn and pass on information. Learning styles are greatly influenced by how a culture socializes with its children and young people." Wikipedia.

⁵⁶ The mission of IEEE Brain is to facilitate cross-disciplinary collaboration and coordination to advance research, standardization and development of technologies in neuroscience to help improve the human condition. The Institute of Electrical and Electronics Engineers is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity.

[Leslee Udwin](#), Founder & President of *Think Equal* has attracted the involvement of distinguished patrons, including Meryl Streep and Sir Ken Robinson who provide [stirring video introductions](#).

Perhaps more immediate actions can be informed by the results of investigations such as reported in the article [How Income Inequality is Messing with our Kid's Brains](#). Many investigations worldwide have provided convincing correlational support for findings such as “simply moving a family’s income out of poverty might be enough to get that child much closer to cognitive developmental norms”. The challenge to determine if these findings are causally supported is underway in a major five-year nationwide study that will include 1,000 low-income families. Writing in [Scientific American](#), the study leader reports that:

“Although income may not be the only factor that determines a child’s developmental trajectory, it may be the easiest one to alter from the standpoint of implementing policy—a down payment of sorts to promote the health of a growing child’s brain.”

More recently *Scientific American* released a special report on [The Science of Inequality](#) covering contributions from: Joseph Stiglitz on “How the American Economy is Rigged”; Virginia Eubanks on “Algorithms Designed to Fight Poverty Can Actually Make It Worse”; James Boyce on “How Economic Inequality Harms the Environment”; and Bo Rothstein on “How the Trust Trap Perpetuates Inequality – Corruption, distrust and inequality reinforce one another in a destructive loop”.

Kentaro Toyama in [Geek Heresy: Rescuing Social Change from the Cult of Technology](#) (2015) and more recently Virginia Eubanks in [Automating Inequality: How High Tech Tools Profile, Police, and Punish the Poor](#) (2018) make compelling cases to introduce technological interventions based on profound understandings of how poverty may be alleviated.

With these compelling cautions in mind, consider the world of Vivienne Ming, theoretical neuroscientist, technologist and serial entrepreneur. We referred to her earlier in the context of a recent SU Summit presentation on exponential technologies having “the capability to enhance and accelerate our abilities, helping us to reach our full potential as human beings by combining neuroscience and artificial intelligence complementing a growing understanding of the human brain to increase dramatically our ability to learn and to achieve”. Her goal: “I want a world where everybody is fully realised. Not just those that can afford it.”

As precursors Ming created [Muse](#), an AI app for parents to interact with and understand their children – reported in [Apps That Aim To Give Parents 'Superpowers'](#) – and the establishment of [Socos Labs](#) – exploring the future potential of humans, through explorations of the potential of machine learning, AI, and even the eventual power of augmented intelligence and neuroprosthetics. Socos Labs is an independent think tank experimenting with whole new visions of work, education, innovation and inclusive economies to inform more human-centered policy. In considering [The Workforce of the Future](#), Ming sets the initial goal as robot-proofing kids by developing their “meta-learning skills – the deeper abilities that enable learning – to produce a generation of problem-solvers”. We return to Ming below in 9.9 *AI in Employment Social Capital*. A recent Ming bio is provided by [Entrepreneurial Scotland](#).

To wrap up this section, consider [this blockchain-based initiative by the United Nations International Children's Emergency Fund](#):

“UNICEF Innovation Ventures team explores these technologies, with the potential to impact children. The team sees blockchain technology as having benefits in 3 main ways: 1) new ways of donating money 2) creating better transparency in internal processes, and 3) leveraging tokenisation to reduce friction in transactions, as well as create new opportunities.”

And the UNICEF startup [Kimetrica](#) – Method for Extremely Rapid Observation of Nutritional Status. Surely a world in which UNICEF is not needed is a world in which *Think Equal* has prevailed.

9.7 AI in Health Social Capital

In section “7. Exports in Medicine & Healthcare” we proposed several prospects for Scotland to export new medical and healthcare products and services from advances in biotechnology, genomics, information and communications technology and their integration accompanied with advances in AI-based, deep-learning applications of customised Big Data sets.

The Scottish Research Partnership in Engineering⁵⁷ has established a [Pan Scottish Theme: Engineering at the Life Sciences Interface](#) which positions Scotland to realise fully the foregoing and in general to benefit from many real opportunities and initiatives in the field of biomedical technologies. More specifically, the University of Glasgow recently established a £15.8m AI health research centre to innovate and transform healthcare to enable enhanced patient diagnosis, treatment and outcomes: [The Industrial Centre for Artificial Intelligence Research in Digital Diagnostics](#) (iCAIRD), fostering a pan-Scotland collaboration of 15 partners from across academia, the NHS, and industry. A recently published overview of [Artificial Intelligence and Big Data in Public Health](#) outlines the significance of AI and Big Data to public health, highlighting issues, including those of an ethical nature, and describing the potential impacts and challenges to medical professionals and diagnosticians.

9.8 AI in Housing Social Capital

AI powered distributed digital technology (DLT) networks are already being established to improve markedly the affordability of housing by facilitating:

- (a) direct secure transfers of housing between sellers and buyers – [A house has been bought on the blockchain for the first time](#), as reported in *New Scientist* (Oct, 2017);
- (b) secure micro investments from anywhere in the world in housing developments through DLT-based enhancements to existing crowd funding approaches resulting in much lower financing costs – [Will AI Drive Real Estate's Future?](#), as reported in *Your Investment Property* (Jan. 2019);
- (c) a significant part of the \$10 trillion pa global engineering and construction market is directed to building housing either in low to medium density residential estates or high-rise complexes – in [AI: Construction technology's next frontier](#), McKinsey (Apr, 2018) outlines the massively reduced cost benefits that AI will deliver to a sector currently low in adoption but now very aware of the potential of AI;
- (d) many working initiatives, reports and articles exist proving and reasoning the massive improvement in housing affordability and national productivity that would arise from the introduction of a land value tax (LVT), starting with Adam Smith, *Wealth of Nations*, Book V, Chapter II, ["Of the Sources of the General or Public Revenue of the Society"](#):

Both ground rents, and the ordinary rent of land, are a species of revenue which the owner, in many cases, enjoys without any care or attention of his own. Though a part of this revenue should be taken from him in order to defray the expenses of the state, no discouragement will thereby be given to any sort of industry. The annual produce of the land and labour of the society, the real wealth and revenue of the great body of the people, might be the same after such a tax as before. Ground rents, and the ordinary rent of land, are therefore, perhaps, the species of revenue which can best bear to have a peculiar tax imposed upon them.

- (e) it is expected that AI-big data-machine-learning will soon circumvent the most common LVT critique, the practical difficulty of measuring land value.

Perhaps even greater than full implementation of the foregoing will be the contribution that AI and 3D printing will make to delivering not only highly affordable housing but also inspirational living spaces anywhere in the world using local natural resources. As current advanced investigations by [NASA 3D Resources](#) to print 3D housing on Mars, using available natural resources, progress to construction of demonstration sites on Earth, it is likely that there will be spin-off advances accelerating the 3D housing initiatives in Highland Scotland outlined earlier in this Overview; namely,

3D printing of houses for less than \$10K – [video](#) & [article](#) – using on-croft grown hemp for the production of fibre and hurd used to produce carbon negative hempcrete for onsite/on-croft building (see [hempcrete in building](#)⁵⁸ and [Mirreco](#)⁵⁹). Then consider making these houses autonomous with a larger flat roof surface serving as a water tank to catch rainwater and providing additional outdoor living space. Add to this [3D printed ultra-low cost, high efficiency solar panels](#) on the flat roof and the external walls clad with sheets

⁵⁷ SRPe comprises a collaboration between three regional research partnerships based around institutions in Edinburgh ([Edinburgh Research Partnership](#)), Glasgow ([Glasgow Research Partnership](#)) and Aberdeen and Dundee ([Northern Research Partnership](#)).

⁵⁸ Hemp is an excellent growth crop with many farming and environmental benefits: (a) hemp crop produces nearly 4 (four) times as much raw fibre as an equivalent sized tree plantation; (b) trees take approximately 20 years to mature... hemp takes 14 weeks. (c) hemp needs no pesticides because it is unpalatable to insects; (d) hemp needs no herbicides because it grows too quickly for any weed to compete; (e) hemp can grow in virtually any climate and soil condition, and is excellent for reclaiming otherwise unusable land; (f) hemp crops rejuvenate poor soils; (g) between 1.7 – 1.9 tonnes of CO₂ is absorbed from the atmosphere for each tonne of hemp cellulose produced (typically 10 tonnes of hemp straw per hectare is grown).

⁵⁹ Mirreco has developed a specialised machine that can process an entire hemp plant into separate items that are individually valuable such as food seeds and oil, fibres and the hurd. The company intends to manufacture, sell and/or own and operate a fleet of mobile machines to process hemp onsite at farming locations and to manufacture building panels for housing solutions using hemp biomass.

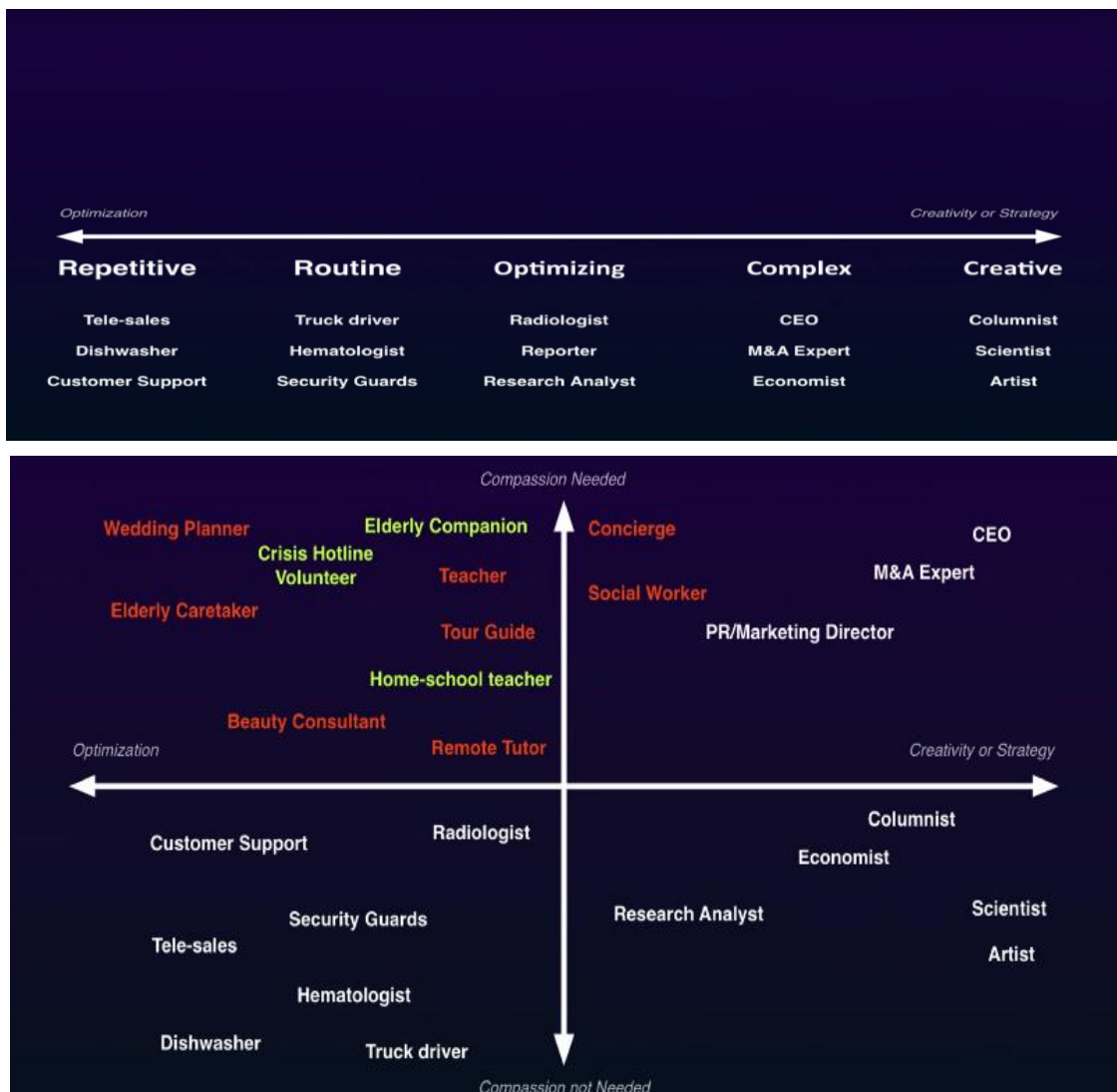
of [3D printed solar cells, using seaweed extracts](#). The 3D printed versions of these [roof mounted wind turbines](#) (perhaps adapting this [3D printing process](#) for large blades) would then generate more than sufficient supplies of energy regardless of the weather, especially if the cost of battery storage continues to plummet, possibly with this [seaweed-based advance](#). Provide a 5G service and the occupants can interact at ever more advancing levels of communication/data-sharing/computation with any groups anywhere and elder citizen occupants can be supported by an ever-increasing efficacy of telehealth monitoring and supporting drone services.

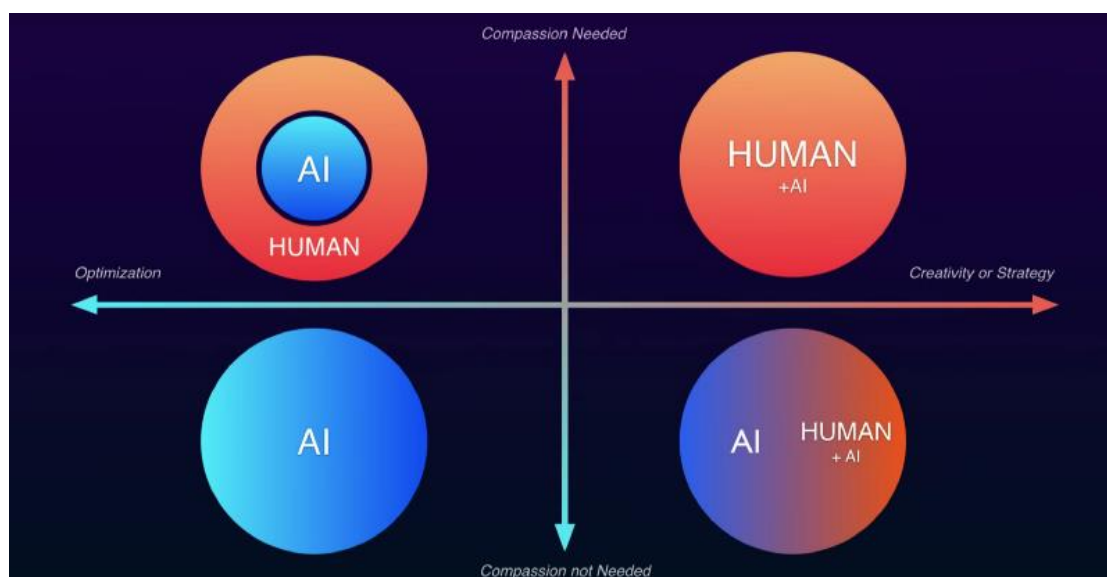
While various innovations are now available to the wealthy in creating smart homes, as described in a series of podcasts on the [Future of Homebuilding](#), from conducting myriad household chores to “knowing and caring for you”, it is likely that these will become increasingly affordable and available to of all who choose accordingly.

9.9 AI in Employment Social Capital

The article [Artificial Intelligence and the Future of Work](#) reports a 2013 study found 47% of US workers held jobs at high risk of automation in the next decade or so, necessitating the creation of 100 million new kinds of jobs. Big tech will contribute but societies are facing realities such as Silicon Valley’s three largest companies had 190,000 workers in 2016 contrasted with the more than the order of magnitude 1.2 million workers for Detroit’s three largest companies in 1990. Now AI is learning to automate beyond routine manufacturing jobs to non-routine jobs in transportation and logistics, legal writing, financial services, administrative support, and healthcare.

We are gradually comprehending that jobs requiring compassion and empathy will not be readily automated. The same applies to jobs requiring high levels of creativity or strategy with varying levels of AI augmentation. Jobs requiring both will require relatively less AI augmentation. This is depicted succinctly in the following graphs from [Kai-Fu Lee’s Ted Talk](#), drawn in turn from his 2018 book [AI Superpowers: China, Silicon Valley and the New World Order](#).





Earlier in this Overview we considered that for innovation to create new value there is a need to align and mesh purpose, leadership, strategy and culture. We concluded that culture needs to be the force multiplier. And yet from the foregoing we see that technological innovation is changing faster than culture. As an example, using AI supported analyses of a powerful dataset of 122 million professional profiles, Vivienne Ming demonstrates that there is a culture-driven⁶⁰ [“hidden tax on being different”](#) resulting from the computable costs to women, LGBTI people, and those from ethnic minorities having to fight much harder to get by at work. This tax has its greatest impact “on those least able to pay it, defying any concept of fairness or economic incentive.” Ming has determined that, all up, the scale of this tax in the US is rivalled only by the total combined federal tax revenue of \$3.2 trillion. It is collected globally such that “vast amounts of money and productivity are lost as a result, impeding growth and stagnating economies”, perhaps on a scale of regressivity even greater than the direct impact of the hidden tax.

Without intervention, the potential for exploitation of [millions of gig economy](#)⁶¹ [workers](#) around the world will intensify as AI is increasingly used to harness their work from crowd worker websites/platforms – “paying as little as \$1 an hour for individuals to perform short, repetitive tasks, such as identifying images as seen in pictures and churning out product reviews”. Add to this the opaque nature of mega projects harnessing inputs from many thousands of workers without advising them that they are working on moral questionable or politically controversial activities. An example, at Google an open rebellion broke out, leading to resignations of several employees, over a project for the US Department of Defence “to build out the Pentagon’s battlefield drone capability”. Not only that Google executives were caught out stating that the contract was for \$9 million, while internal documents revealed an expected “ramp up” to \$250 million.

At the other end of the scale to the gig economy workers we have the world where building social capital in education, health, housing, employment and belonging is focussed on producing a workforce of “crafters”, who are either *creators of great skills in the manual arts* or *creators of applications fostering creativity, adaptivity, resilience, and capacities for problem specification & exploration*. A reading of section “5.5 Scoping the Extent of Eco-Industrialising the Highlands and Islands” and section “5.6 Crofting as a Catalyst for Hydrogen Scotland Development and Eco-Industrialisation” outlines one possible milieu for the emergence of the earliest workforces of crafters, in this case permeating Scottish crofting communities. In time, if Ming is right, all humans will have choices to utilise advances in AI and neuroprosthetics to ascend greater and greater heights of *craftership*, perhaps our best guarantee for ensuring the benevolence of AI.

⁶⁰ When given identical CVs controlled studies find that many employers: (a) prefer male names over female names; (b) ‘Caucasian’ names are preferred to ‘African American’ ones; (c) bias exists in simple email introductions; (d) bias persists even for matching gender and ethnicity.

⁶¹ A gig economy is a free market system in which temporary positions are common and organizations contract with independent workers for short-term engagements. The trend toward a gig economy has begun. A study by Intuit predicted that by 2020, 40 percent of American workers would be independent contractors, albeit, in most cases without any of the rights or entitlements of employees.

9.10 AI in Belonging Social Capital

We've left behind a world where we had less connectivity but more connection. The more hyper connectivity, the more the need for connection. Connection creates belonging. Connection prevents social isolation.

In this recent Forbes article on [Belonging: A Fresh Look at Engagement](#), the reader is asked "What is the leading cause of mortality selecting from (a) high blood pressure, (b) high cholesterol, (c) inactivity (no exercise), (d) social isolation, (e) fast foods, (f) alcohol, (g) obesity, (h) depression and is provided with the answer (d) social isolation, with the explanation "This may surprise you. But in this high-tech age when it's so easy to peek into the lives of complete strangers, more and more people are feeling isolated."

Other thoughts from this article include:

- Belonging requires effort
- Belonging requires making social media more social
- Belonging requires empathy
- Belonging requires that people are agents for themselves
- Belonging requires us to use technology to create and build connections not contacts
- Belonging requires us to act on the realisation that the tech-enabled global village can increase isolation

With this in mind it should be possible for the current rise of online processes facilitating many forms of sharing – including cars, accommodation, garden produce, local bartering – to achieve social good if they are built cognisant of social inclusion, sustainability and other societal challenges. This article provides an account of successes in [How technology can help combat loneliness and social isolation](#).

And what of public sector initiatives to help deal with loneliness and social isolation? In the UK the Office for National Statistics found that those aged 16-24, expected custodians of our collective futures, felt lonely more often than any other age group, sufficiently concerning for the UK Government to appoint a [Minister for Loneliness](#).

Variations on the AI-big-data based proposals outlined in section 7.7 *Destressing Medical Practitioners* and 7.8 *DLT-Based Application to Assist in Coping with Depression and Suicide* could be worth considering.

Also worth consideration are the capacities to build the various types of belonging outcomes inherent in the proposed development ofcrofting communities as envisaged in section "5.5 *Scoping the Extent of Eco-Industrialising the Highlands and Islands*" and section "5.6 *Crofting as a Catalyst for Hydrogen Scotland Development and Eco-Industrialisation*".

9.11 AI Benevolating AI

In section "9.9 *AI in Employment Social Capital*" we touched on the prospects for humans enhancing their intellectual capacities to match but not replicate advancements in artificial intelligence thereby greatly increasing the chances for evolving ethically, harmoniously and mutually reinforcing together. Creation of mathematics will be needed to pave the way. We have already mentioned in section "9.5 *Trust as a Preeminent Social Capital Resource for Benevolent AI*" an application of mathematics and its algorithmic expression to assess the impacts of fake news. A similar application to Knowledge Graphs, spanning as noted in section "9.1 *AI and Classical Economics*", the works of Smith, Chomsky and Minsky, the work and publications of the public and private entities outlined in the lead into this chapter, and the burgeoning range of articles (and their reference sources) on ethics and AI, such as listed in section "9.4 *AI and Ethics*", could generate not only insights pointing to effective pathways to advance benevolent AI but also create a capacity for identifying unexpected pitfalls of AI advances and recommending proposals for their containment.