Making zero growth socially sustainable

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Abstract

The successful implementation of robotics, the operation of instruments and devices by robots without any significant degree of human interference threatens to make human workers redundant. A recently attended lecture about the current capability of robotics, illustrated the rapid rate of development of, for instance self driving motor vehicles. There are still certain shortcomings in the current state of this particular type of robotics, mainly concerning the ability to anticipate unpredictable behaviour of other road users. Nevertheless self driving cars are already much safer than human driver driven ones. Accordingly, we expect robotics to become a significant source of labour replacement in other contexts. We therefore plead for a change in cultural ethos and fiscal regime. The social norm should be based on an active lifestyle, involvement in pursuits valued by society rather than in activities solely undertaken for financial rewards. To allow this to happen, public authorities should collect the rental value of the earth's limited capabilities in the form of taxation on specific activities. As the title of the article indicates, the purpose of these charges is to reconcile zero growth with social stability. For this reason activities assumed rather than confirmed to be potentially harmful should also be charged. The revenue would then become available for two objectives, namely: To provide every citizen with a guaranteed minimum income as well as building and managing adequate facilities for people to remain active. This should be seen as an essential public function rather than the provision of superfluous luxury 'leisure' facilities.

Introduction

Our present-day society is addicted to economic growth. This is the case because the societal norm is to earn one's living by working, which means that those fit and of working age, who are not in work, are seen as scroungers. Changes in technology, in particular the rise in automation and robotics, are leading to an increase in production per worker. To illustrate the degree to which robotics is already performing more successfully or to at least equal standards as human operators, we provide some information concerning self-driving motor vehicles, relying on the report (of the attended lecture) from Scientist for Global Responsibility (2018) and a range of internet references. We find that robots already have a good safety record by comparison with human drivers even though there is still room for improvement of optical instrumentation and recognition software, as well as anticipation of the behaviour of other road users. In our opinion there is a reasonable expectation that even safer and more capable self driving cars are not beyond the realm of the possible. Potentially, the technology is equally applicable to other processes in areas where there is less (real or perceived) risk of malfunctioning of lethal or seriously harmful results. Accordingly, we expect other potential areas of use of robotics to become more appealing to the public. However, this implies that individuals currently in employment might become redundant, when robots could fulfil their tasks equally well without the need for wages or salaries.

In the age of robotics the combination the social norm of working and increased production per worker requires a faster rate of growth than at present. It is argued that, even whilst it may perhaps be possible to find the means of repairing some forms of damage to the earth

associated with economic growth, new and unexpected types of environmental destruction are a practically unavoidable result of continuing on this path. To illustrate the risk of unintended consequences, we survey some unforeseen forms of damage that have occurred, rather than some of the better known threats such as climate change and black carbon pollution The paper therefore emphasises the need to explore the possibility of building a society without open ended economic growth in order to overcome the compulsion to work and the harm to the earth which this implies. In our view this can only be realized by ensuring that those who would lose their existing jobs are not only provided with the means to live and look after their families, but also with measures to meet with the individual's need for a fulfilling activity. This might also require financial support for retraining for professions that still need additional workers

The process of growth, its drivers and implications

Production of goods makes demands on the earth's natural capabilities and raw material supplies, while also requiring labour by human beings. The same applies to a significant extent to services: Even while primarily depending on human effort service activities also make use of energy and raw materials. Both types of production use equipment, the aggregate of which is known as *capital stock*. There are two main ways in which investment in tools for future production can result in enhancing growth. These are associated firstly with a straightforward expansion of the capital stock, bringing (the possibility of) an equivalent expansion of production in its wake, and secondly on the replacement of a particular production activity, using other more efficient types of equipment than in the past. The latter ensure more production per unit of labour and / or environmental resources. The obvious example of investment to increase production per worker consists in computerization and robotics.

Although robots use energy, they nevertheless could be instrumental in reducing the energy use per units of product. ABB Robotics division, (2018) mentions an obvious point: Robots do not have the same need for heating and lighting of their workspace as human workers have, an issue which immediately generalizes to air conditioning.

As to motor cars, this issue was evaluated by the University of Leeds (Energy Leeds, undated). That report lists a number of reasons why robot driven cars may save energy, but also one reason why the opposite might apply. The crucial issue that robots drive with greater precision is somewhat awkwardly formulated as "lower engine performance requirements", meaning that the robot-driver will make a lower demand on the engine's capability. This study also lists *one* reason why the opposite might apply. "Higher speed limits resulting from increased safety". This reported reason for a higher energy use by self-driving cars needs to be qualified on several points. Automated cars have indeed a much better safety record than human-driven ones. The cause of this accident involving a robot-driven car was reported as:

> [⋯] the cameras weren't able to effectively differentiate the white side of the tractor trailer against a brightly lit sky. (Ackerman, 2016)

Clearly this particular brand of automated car (Tesla) needs another look at its optical instrumentation and its coordination with the computer, so as to make sure that it is up to the same standards as an alert and competent human driver with good eyesight.

As to the driving speed, enforcement of speed limits on automated cars is more straightforward than in the case of human drivers; where the police needs to construe *the specific time* the speed limit was exceeded *at a particular location*, instead of the consistent behaviour of automated cars.

In any case we are a long time off from the time when speed limits can safely be increased because *all* cars are driven by robots rather than by mistake-prone humans. Even so, there remains a case to maintain the current limits for the sake of containing fuel use.

A possibly more systematic reason was reported in relation to an accident where a pedestrian was seriously injured and subsequently died in hospital. One of the relevant issues here is that there is a trade-off between safety and smooth progress in urban traffic. Self-driving cars normally have an option to relax maximum safety, whilst allowing the (so far required human) driver to intervene.

> "The preliminary report released Thursday by the U.S. National Transportation Safety Board into a fatal Uber crash in Tempe, Arizona [……] the automated braking that might have prevented the death of pedestrian Elaine Herzberg had been switched off "to reduce the potential for erratic vehicle behavior." Such functions were delegated to the driver, who was simultaneously responsible for preventing accidents and monitoring the system's performance. (Fickling, 2018)"

In fact, as in the 2016 case, more advanced optical instrumentation and recognition software could almost certainly have prevented this accident, irrespective of any reliance on interference by a human driver:

> "Self-driving Uber vehicle DID detect woman moments before fatally running her over in Arizona - but didn't stop because 'it didn't recognise her as a human' " (Zieber, 2018)

Nevertheless, the 2018 Arizona accident is reported as being the first one in which a pedestrian was killed (The Guardian, 2018). That makes it clear that self-driving cars are already much safer than those driven by human drivers. We found a reference to self driving cars possibly resulting in an in an increase in fuel consumption (Boyle, 2016). That was based on the assumption that there would be more use of cars rather than on any increase of fuel use per kilometre. In fact we are not convinced that the present limitations of optical capabilities and camera orientation of self driving cars that the technology allows at present, could not result in an increase in the fuel use per kilometre. The 2018 Arizona accident illustrates why. A good human driver would have looked not only straight ahead on the road to be driven but also at the pavement and noticed the pedestrian with her bicycle about to cross the road. Bicycles are for use on the road and not on the pavement, and the risk of a careless pedestrian (with or without a bicycle) stepping into the road should have been anticipated. How many times was an accident avoided by a car braking, whereas a timely reduction in speed by easing off the throttle when observing pedestrians would also have saved fuel? We are convinced that further improvement in optical instrumentation and recognition software is possible and likely to be implemented. And it should include camera orientation aimed at anticipating careless actions of pedestrians, stepping into the road in front of approaching cars.

Perhaps existing legal requirements on the presence of a driver in a motor vehicle and other means of transport and a (contra-factual) public perception of the risks of robotics, will at the very least slow down the redundancy of human workers in the transport sector, despite the demonstrated safety characteristics. Even so, we are convinced that a significant displacement of human workers by robots will be the next step, possibly in the form of driverless taxis, and in any case in less regulated activities, such as window or floor cleaning. Here too, the energy and raw material requirements to operate a particular item of equipment could become less when the operator is a robot. However, the risk of malicious interference with the control programs should not be underestimated. This is a broader issue, which the SGR report (Scientists for Global Responsibility, 2018) mentions in relation to weapon

systems, commercial or industrial espionage, and manipulation of public opinion via social media. But clearly, safeguards against hacking someone's taxi (by intercepting a 'phone call, at a taxi pickup point or otherwise) and using it to travel to the other end of a country, or to kidnap the legitimate passenger(s) are in order.

The implied increase in the demand for natural resources

As long as working remains the norm, the worker whose job is taken over by a robot will keep using energy whilst doing something else. Let us further assume that the number of human workers and their working hours remains unchanged rather than being reduced as argued here it should be. The replacement of human labour by that of robots implies a drastic increase in production per worker. Energy use per unit of production may drop, but production per human worker will increase drastically due to robotics.

Unfortunately, the standard economists' response to guarantee employment for all those who can and want work is as good as ignoring to a considerable extent or at least neglecting to recognize the environmental implications of increasing production. Accordingly, the recommended remedy is called "demand management" which means ensuring that the population has the financial resources to purchase the products.

There will in all likelihood remain types of products for which work by human beings cannot readily be replaced by robots. Indeed, there is a view that automation actually creates new job opportunities because it becomes possible to perform activities that were problematic in the past (Lohr, 2016, referring to Bessen, 2015). The latter author also reports that statistical estimation contradicts the intuitively plausible proposition that computerization reduces employment: the growth of output in the more computerised industries more than compensates for any job losses.

> "Employment grows significantly faster in occupations that use computers more." (Bessen 2015)

In a somewhat similar vein, Smith (2018) reassures people who fear unemployment with the words:

> "Automation will dominate some fields. But people will want new things, and new industries will arise."

However, none of these authors mentions the environmental cost of higher levels of production.

In fact, the drastic increase in output implied by the recommendation to overcome the reduction of job opportunities created by robotics by way of producing and consuming even more is bound to result in a great increase of the demand for energy and natural resources. This is something we cannot afford on the Finite Earth.

What also needs mentioning in relation to the threat of unemployment is that it affects not only those unable to find work. We discussed the relationship between unemployment and an unequal income distribution with low wages in some detail elsewhere (Heesterman and Heesterman, 2013: 92*ff.*). Suffice it here to say that (at least according to the economic theory framework presented there), unemployment breeds exploitation, because where individuals are unable to find employment, desperation will force them to accept work on any terms

In short, the process of economic growth as its works our present-day society gives rise to a considerable tension between social and environmental sustainability: Social sustainability requires

further (and faster) growth, but, as we shall document in more detail in the following section, unrestricted growth destroys the earth. This may not have been the anticipated result, and indeed, there is still uncertainty about the extent to which particular technologies are (were found to be) environmentally destructive.

Why growth needs containing

A lifestyle under which luxuries like, let us say, a rocket trip around the globe to view it from space would be a holiday option for high-earning individuals, is thinkable. And yes, it might perhaps ensure paid work for all those who need or are expected to find it. However, the earth might be wrecked in the process.

The development of new types of products, including new synthetic substances is a more or less inevitable facet of the development of "new industries" referred to by Smith (2018) above. However, many, if not most, of these new synthetic products leave an indelible stamp behind on the natural world, as may be illustrated by the contamination of natural environments or resources with chemical compounds that have long since been accepted as a normal part of our lives.

Microfibers and micro-plastics

Plastics, as originally developed in the late 1940s and 1950s do not degrade on a timescale with any relevance for the living generation of humans. The two main sources from which pieces of plastic break down in very small pieces are car tyres and clothing. (Plastic Soup, 2017). Following concerns about plastic pollution, two new kinds of plastic were developed. Most biodegradable plastics are, chemically speaking not really the same product as the original type, as they are created on the basis of starch or other agricultural products (Woodford 2018). There are also oil-based plastics, which are chemically processed to decay in the presence of light. The latter method involves the replacement of one or more of the hydrogen atoms attached to the carbon chain of carbohydrates (alkanes) by atoms of groups of atoms that react to light and then rupture the carbon chain (Royal Society of Chemistry, 2016). Conceivably, light-degradable plastics could also be made more fully sustainably, using synthetic oil-type products (Heesterman 2018, referring to Audi's e-benzin and e-diesel), produced from carbon dioxide, steam and (renewable) energy. In the light of what we now know about plastic pollution, it is a major misfortune that these types of plastic were not developed much earlier.

Whilst natural fibres like cotton and wool degrade back to their source substances by biological processes, synthetic fibres break mechanically down into tiny, near-invisible pieces, called micro-fibres. These get into sewers, rivers and eventually into the oceans, where they can absorb toxic chemicals and pathogens (disease causing agents) and are eaten by marine organisms and accumulate further in the food chain, i.e. are either eaten by larger animals such as fish or seals (House of Commons environmental audit committee: 2016; see also Messinger: 2016). Large amounts of micro-fibres also land directly on farmland in sewage, which although decontaminated by sewage works, is used as fertilizer (Farming life, 2017). Micro-plastics have also been observed in the atmosphere, in indoor and outdoor environments and some of them may be inhaled. Medical experts (Gasperi et al 2018) also fear – without presenting any clear evidence- that ingestion of micro-plastics could lead to infertility, cancer and genetic defects, due to their tendency to amalgamate with other toxic substances, notably associated contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs) and chemical components of the plastic itself such as dyes. Note also, that whilst there is extensive evidence of the presence of microfibers in a range of environments, we have not found any evidence of the presence of these particles in plant-based food, except in

the case of beer, where they could have come via the atmosphere, rain and water. Microscopically small pieces of plastic have recently been discovered in human stools. Due to the small sample size (8 individuals, living in 8 different countries, and all 8 testing positive) it is less than entirely clear how they were ingested.

> "All participants were exposed to plastics by consuming foods that had been wrapped in plastic as well as beverages in plastic bottles. None of the participants were vegetarians, and six of them consumed wild fish." (Neimark, 2018)

Larger pieces of plastic

These are bound to disintegrate into smaller pieces. Whether these will be as small as the torn shreds of material emanating from washing machines, and on what timescale, we would not want to comment on. However, bigger pieces appear to be capable of killing large animals: A dead sperm whale washed up on a Spanish beach and the poor animal had 29 kilo plastic in its stomach, including whole plastic bags, pieces of fishing nets and a jerrycan. (Gabbatiss, 2018).

In a similar vein, Gill (2018) reports on what the film crew making the BBC documentary "Drowning in plastic" observed. There were dead chicks of a particular kind of seabirds (flesh-footed shearwaters), who had hatched on Lord Howe island and whose stomachs were full of pieces of plastic, which their parents had picked up for them at sea as "food". These chicks were apparently so underfed, that they were unable to cope with their first move into the ocean.

Exhaust fumes

There was a time when the usual type of fuel for cars was petrol / gasoline. As higher compression rates help engine efficiency, lead was used to avoid the air fuel mixture from igniting before the ignition system generates a spark to that purpose. The relevant lead compound appears to be (have been) tetraethyl-lead: four ethyl groups, each of them having one valency linked to one common lead atom. This compound readily mixes with petrol, but to avoid lead accumulation in the cylinders, chlorine and bromine compounds were added to the fuel as lead scavengers (Wikipedia, 2018a). Fortunately, there is a substitute for tetraethyl-lead as an anti-knock agent in internal combustion engines. Of these, MTBE (methyl tertiary-butyl ether) has the drawback of being water-soluble and a groundwater contaminant (Wikipedia, 2018b). It is also possible to selectively use only some of the more suitable components of crude oil (*ibid*), but that leaves the question of what to do with the rest. Blending with ethanol (ordinary alcohol) can have the same result, albeit at the expense of a reduced engine performance.

Teflon

Teflon is a commonly used synthetic material with the chemical name Perfluorooctanoic acid, often abbreviated as PFOS or PFOA or,, by reference to its carbon chain core as C8. One of its more widely used applications is the "non stick" coating on cooking and frying pans. And it has been found to be carcinogenic.

> "Studies in lab animals have found exposure to PFOA increases the risk of certain tumors of the liver, testicles, mammary glands (breasts), and pancreas in these animals. In general, well-conducted studies in animals do a good job of predicting which exposures cause cancer in people. But it isn't clear if the way this chemical affects cancer risk in animals would be the same in humans." (American Cancer Society, 2016)

The third sentence of the above quote is disingenuous. It may be that, due to its low solubility in water and its solid form, the ordinary user of Teflon is not exposed to any significant dose of this chemical, but staff making and processing the substance is another matter.

> "The C8 Science Panel studied 55 health outcomes and, between 2011 and 2012, delivered four reports to the court concluding that PFOA was probably linked to six outcomes: kidney cancer, testicular cancer, ulcerative colitis, thyroid disease, hypercholesterolemia, and pregnancy-induced hypertension." (Nicole, 2013)

Although the company was aware of PFOA's toxicity, it did not inform the E.P.A. and continued to use the compound in the manufacture of its kitchenware:

> "For decades, chemical giant DuPont knowingly allowed a cancer-causing chemical (Perfluorooctanoic acid or PFOA), used in the manufacture of Teflon, to pollute the air and drinking water in West Virginia. Years after the practice was uncovered and made public, the company finally discontinued its use of the toxin." (Rich, 2016)

Obfuscation and misinformation by commercial bodies is all too common, when unwelcome features are identified in one of their products, and the financial implications are detrimental to their business. (Oreskes and Conway, 2012),

A poorly identified planetary boundary

We mention one other issue of uncertainty. It relates to aircraft exhaust fumes. Barrett, Britter and Waitz (2010) estimate that world-wide something like 8000 premature deaths per year are due to aircraft emissions, of which they reckon a significant part to be related to flying at cruising height. The problem with this study is that the question whether the human body has a tolerance level to inhaling toxic materials, below which they have no effect, is asked only for the finest soot particles, for which they report that there probably is no tolerance level. That question is non-trivial. However, given the problems around trying to estimate the relation between the amounts of toxic substances in the air and mortality by means of statistical observations, that is also a to all practical purposes unanswerable question.

Global diffusion of pollutants

It has been known for some time that many pollutants even occur in the bodies of polar bears far from where these originated (IUCN, 2009; Walker, 2010). Arctic Ocean pollution arises because sea currents transport anything ending up in the water.

Given the northward flow of the Gulfstream / North Atlantic drift current in the Northern Atlantic, pollutants generated further south end up in the food of polar bears

The devil's advocate case: the environmental Kuznets curve

The term "environmental Kuznets curve" arose by analogy to Kuznets's (1954, 1955) argument that economic growth may be kickstarted by investment requiring inequality but that eventually "the view of society" will give rise to a more equal social order. The generalization of this idea to the relation between affluence and the environment is summarised below by a quote from Stern (2003)

> " [ ] .. in the early stages of economic growth degradation and pollution increase, but beyond some level of income per capita (which will vary for different indicators) the trend reverses, so that at high-income levels economic growth leads to environmental improvement."

Stern concedes that there are statistical problems with verifying this "law". However, if that were the only limitation of the environmental Kuznets curve assumption it has to be noted that this is true for a many economic relationships. And it is indeed the case that technological remedies have been developed for many forms of environmental degradation. The development and falling costs of renewable forms of energy is an obvious recent illustration. There are, however, logical, societal and factual observation problems with this contention.

Firstly, Rockström et al (2009a; 2009b) have a point: the earth is finite and by implication cannot support open-ended ever increasing production. These two articles by the same group of authors are textually quite different. Nevertheless they have in common the idea that the capabilities and tolerances of the earth can be identified. These authors made a credible attempt to identify what the limits actually might be of maintaining a sustainable level of exploitation of natural resources. The same idea, that is a well-defined or at least knowable resource basis, within which human society can safely operate is also conveyed by the title "doughnut economics" of (Raworth, 2017).

It is argued here that such identification of the shape of the doughnut is an impossible task. In In addition, there is in the market economy a systemic incentive towards obfuscation and misinformation by commercial bodies. When unwelcome features are identified in one of their products, and the financial implications are detrimental to their business, obfuscation and misinformation by commercial bodies is all too common (Oreskes and Conway, 2012). The earth has a wide range of capabilities and resources. In addition, we cannot always recognize which processes have the potential to damage the earth, before it is apparent and its cause has been established. Indeed, a particular technology could wrongly be identified or over-estimated as harming in a particular way. A threat to the ozone layer mentioned by Gribbin (1990) is the injection of water vapour into the stratosphere by (high flying) supersonic jets. Gribbin referred to Juan Cisneros, at a participant of a conference in Madrid, organized by Greenpeace. We have been unable to trace the text of his actual words, but we take it that Cisneros was the source of Gribbin's concern about water vapour in the stratosphere. It is indeed the case that combustion of carbohydrate fuel by aircraft causes the emission of water vapour. However, theoretical calculations indicate that the effect of a doubling of the water vapour concentration in the ozone layer would reduce its ozone content by as little of only 1 percent (Hesstvedt, 1973). A more significant threat to the ozone layer from supersonic aircraft could have arisen from the sulphur in their exhaust fumes (Pearce, 1979, referring to Kärcher and Fahey, 1979). A particular concern in relation to the sulphur emissions of aircraft could be the generation of sulphur trioxide rather than sulphur dioxide, a compound which is more known as a hazard at ground level.

We now know that the key ozone destroying agent is chlorine (Molina and Rowland, 1974). On the natural earth chlorine would not reach the ozone layer. However CFC (Chloro-Fluor Carbon) compounds are very stable at ground level but will dissociate and release Chlorine under the impact of the lethal, very short wave ultra-violet component of the sunlight, from which the ozone layer shields the earth (The Ozone Hole, 2018). To a lesser extent this also applies to the later developed HCFC (Hydrogen Chloro Fluor Carbon) compounds. In addition, some of the ice crystals in *polar stratospheric clouds*, which form at very low temperatures, can be covered with a thin layer of sulphur compounds, which appear to enhance the ozone destroying properties of chlorine (Bogdan et al, 2010). The injection of water vapour (and sulphur) into the stratosphere could possibly have enhanced ozone destruction by supporting the formation of this type of clouds. However, as far as the water vapour is concerned, normal atmospheric circulation of air, in the form of warm air rising in

the tropical climate zone, including extreme heat leading to tropical hurricanes, then flowing poleward at high altitudes and sinking in the polar climate zone, seems to be at least as plausible a source of stratospheric water vapour as supersonic aircraft. As far as the latter are a threat to the ozone layer, it appears to be due to any sulphur in their fuel. It should in that context being borne in mind that on the natural earth, both chlorine and sulphur are pretty efficiently being washed out of the troposphere, the weather-making lower part of the atmosphere with the formation of rain and snow, although not out of the stratosphere.

There also is a range of forms of damage to the earth which are well known to concerned scientists, for which there is nevertheless as yet not much public perception that they imply a threat to normal life for humanity. A possibly catastrophic loss of biodiversity, known as *The Anthropocene Mass Extinction* is an obvious example (Wagner, 2011).

It is, however, argued here that it is (as yet) *unrecognized* threats to the earth which are the most dangerous ones, because we do not have the knowledge whether a technological remedy exists, and even if this is the case, there will inevitably be damage to the earth, before the remedy is not only found, but also implemented.

There also is an issue as to what extent the threat to the earth is taken as seriously as it should. Thus Kuznets (1954, 1955:9) mentions "the view of society" as the basic driving factor to reduce inequality. That "view" may have appeared to be present to Kuznets in the heyday of the Welfare State / New Deal period. However, sadly, such a view has, with respect to inequality, largely been replaced by market fundamentalism, whilst society's view on the urgency of environmental issues appears to be inadequate in so far as phasing out fossil fuels at a speed which gives us a fair chance to contain climate change, and is almost lacking in relation to other forms of environmental degradation. Lack of prompt action on phasing out the production of dangerous substances is not only an issue of inertia. It is also at least in some cases, aggravated by manufacturers, who omitted to disclose the harmful nature of their product, although being aware of the fact. For example, Dupont and the original developer of Teflon, the Minnesota Mining and Manufacturing Company ("3M") knew since 1970's that "C8" was toxic, but carried on producing and selling it anyhow (Lerner, 2018).

We have nevertheless to assume that (possibly by learning this the hard way) the required "view of society" will become sufficiently manifest to be able to face the financial cost and economic reorganization in pursuit of near-complete decarbonisation. Otherwise *The Economist* (2018) with its leader title "The world is losing the war against climate change" could well be right.

We cannot rely on the Environmental Kuznets curve, because we might not timely identify threats to the earth, nor, if we do, timely find a remedy, or indeed on identifying the correct remedial action. Nor can we be sure that there *is* one.

Why we need a societal change

Calling a halt to further growth without any thought of the employment implications and social iniquity would lead to widespread grief and social unrest. There is a need for radical change in today's social structure. This is our approach towards resolving the conflict between the environmental and social constraints.

We now proceed to discuss our approach towards resolving this potential conflict,

We mention at this point that there was at least one well known economist, John Maynard Keynes, who expressed the opinion that economic growth would in any case dwindle of its own accord and remedy the issue of unemployment by people simply working shorter hours.

> "Three-hour shifts or a fifteen-hour week may put off the problem for a great while." (Keynes, 1930, 1931, 1933: 369)

Keynes was not particularly concerned about the environment or resource depletion, which was not an issue of the same importance in his days as it is currently. Rather, he felt that more and more money and luxury would not really benefit anyone.

> "The love of money as a possession -as distinguished from the love of money as a means to the enjoyment and realities of life- will be recognised for what it is, a somewhat disgusting morbidity, one of those semi-criminal, semi-pathological morbidities which one hands over with a shudder to the specialists in mental illness" (*Ibid*, further down)

We would, however, question Keynes' remedy of a uniform reduction of the working week: Such work as needs to be performed in the age of robotics consists of tasks for which a robot cannot be programmed. That may include work which requires a human touch, i.e. empathy with frail, elderly or disabled people. Also, a fair amount of the remaining work in the age of robotics requires a level of expertise and judgment that cannot be acquired and maintained whilst studying or working only 15 hours per week. It requires a full time commitment and if 15 hours were the norm, it would give anyone who volunteered to work longer than the standard 15 hours per week a special status. It would in practice give rise to two classes of citizens: those who work (or did so prior to retirement) full time and those who don't and work more than the required 15 hours. And it might well give rise to similar social tensions as unemployment does

Our proposed solution: a citizen's income financed out of rent

As far as the immediately urgent problem of climate change is concerned, assigning a price to CO_2 emissions via a tax on carbon containing fossil fuels appears to be an obvious remedy.

Rent is the standard economic term for a price to be paid for the use of a resource which is naturally available, and for which the demand could outstrip its available supply. Assigning a price to, or increasing the price of a specific resource by taxation is not the only way to restrict its demand. Regulatory interference, i.e. prohibiting or attaching conditions to certain types of activities is the alternative. There are, however, two main reasons why we focus on the market and the price mechanism. Firstly, we reckon that a significant degree of limiting the damage done by humans to the earth by means of fiscal intervention is slightly more politically acceptable than the alternative of organizing a planned economy on the basis of sustainability. Secondly, many of the obstacles against implementing the market approach apply to regular intervention as well. To make this last point clear, we remind the reader of an issue discussed in relation to the issue of uncertainty in the section on the environmental Kuznets curve: the mis-identification of water vapour in the stratosphere as a major cause of ozone depletion. A regulation forbidding aircraft to fly at stratospheric altitude would have been, perhaps not pointless, but certainly inadequate as far as the ozone hole is concerned, and counter-productive in relation to carbon dioxide emissions. Flying lower than the technically and economically optimal altitude, in denser air and therefore at a lower speed

than the craft was capable of, would inevitably require more fuel for a longer flight time over the same distance.

To avoid, if possible, any further risk of unwelcome surprises like the ozone hole and more general environmental degradation, we need to reconcile zero or very slow growth, (at least of already affluent countries) with social stability. To that purpose we propose that individuals be assigned a fair share of the rental value of the earth, in the form of a citizen's income, financed out of charges on natural resources. The idea of a citizen's income has a long pedigree. It is, or at least used to be based on the idea that all people collectively own the naturally available capabilities of the earth. (Paine, 1795).

Paine proposed that it should be financed on death duties on land. We take this to relate to land for which there was a registered owner rather than uncultivated land on which in Paine's time there was no ownership claim. Under modern conditions it would clearly be desirable if charges of this type were on resources which are known to be imperilled. Or on the nearest measurable proxy for these, e.g. a carbon tax on the extraction of carbon containing materials from the earth, because they are likely to be burnt and result in carbon dioxide emissions. However, even if that is not the taxation basis, it still ensures that a citizen's income enables people not to be forced to engage in paid work. To compensate for the increase in accounted production per paid worker we need a reduction in the number of people working for a financial reward. This aim would be attained by a rising citizen's income.

We would hope that the removal of the compulsion to work for money would be matched by a cultural ethos of people taking pride and being seen as good citizens of the earth. They could for example be taking part in schemes to protect nature or organizing and giving an artistic performance, even though not reaping any direct financial rewards for doing so.

The obstacles against timely action

To begin with there is a problem with the cost and the resulting price of energy. When and where primary resources like sunshine for solar energy are locally available, renewables are roughly competitive and are fast becoming cheaper than fossil fuels. However, replacement of fossil fuels by renewable forms of energy at a pace which gives us a fair chance to avoid catastrophic climate change runs into some often voiced obstacles: the intermittency of local supply variable demand as well as the fact that in certain areas the demand is not matched by the local supply of renewable resources like wind and sunshine These obstacles can be overcome, at a financial cost: The spatial imbalance is resolved (at a cost) by long distance transport of energy. There is an HVDC (High Voltage Direct Current) technology, while means to store energy are increasingly coming on the market. In addition electric energy can be used to produce hydrogen by electrolysis of water and further process the hydrogen in combination with carbon dioxide into synthetic carbohydrate fuels, which are more easily transportable. The technology of renewable energy can in principle avoid the worst forms of climate change. There is, however, a delay in implementing it. Some of that delay is perhaps pure inertia, based at least in part on lack of knowledge of the available technology. Clearly, part of the reason for the delay in implementing renewable technologies, is its financial cost as well as opposition from vested interests.

In addition, even if the worst forms of climate change are avoided, other types of damage to the earth, such as biodiversity loss ("The sixth mass extinction" see Caballos, Ehrlich and Dirzo, 2017; World Wildlife Report, Living Planet Report, 2018: "60% decline in the size of

populations of mammals, birds, fish, reptiles and amphibians in just over 40 years") could still cost humanity dear.

We assumed above that there is the collective will to avoid serious damage to the earth whilst also giving people who want to work for money the opportunity to do so. This does not mean that there should be uniform citizen's income for all the citizens of the earth. Nevertheless, it is difficult to see how a global "view of society" to contain growth will be forthcoming if it not also felt to be consistent with building a fairer world. That must mean, irrespective of the emergence of a more coherent form of global governance, some degree of re-distribution of income between affluent and poor nations as well as financial equality within countries.

It is clearly possible that some governments have the will to contain growth and maintain social cohesion by way of establishing a national system of taxation to finance a citizen's income for its own citizens. Any charges on specifics products or processes that are an important cost factor in tradable products would also affect the global price and production levels of the products in question and make it easier for other governments to demand similar moneys for the same process or product. That would apply, even if the revenue were used for other purposes. If that happens in certain countries whilst others remain addicted to growth with people needing to work for financial reasons, it will still help to contain environmental destruction to some extent, but a globally agreed policy would be much preferable.

The societal aspect: active support of "leisure" activities.

Providing people with a guaranteed income is only part of the solution. Human beings need reassurance that they are not being left behind and can still make a contribution to society.

A comment on Robinson and Palmer (2018: Chapter 9, especially p.123)

> "[..] governments must drive investment to places where jobs are lost and stimulate economic development."

is of relevance here. We entirely agree with these authors that financial support is insufficient to ensure that people are not feeling they are left behind as full members of society. Nevertheless, the fundamental position of these authors is that people earn *by working*. They "only" question the fairness of the way in which our current society functions. However, once one accepts that the earth sustains a (finite) amount of livelihoods irrespective of how much work is being performed, a key issue in relation of degrowth is the reference to "job creation" which follows this passage. The creation of new alternative *paid* jobs is possible only if we accept that the growth of production and in consequence possibly new threats to the earth, as explained in the section "Why growth needs containing" earlier in this article, will continue. We argue that ensuring that people have a chance to engage in other (*unpaid*) activities is an essential facet of managed degrowth. This requires a fiscal (public) policy which guarantees people's material livelihood irrespective of the kind of occupation what is under the now prevailing social-economic order known as 'a job'. A secure livelihood is indeed not enough for people to see themselves as being full and respected members of society. Accordingly, there the task for governments is to collect the rental value of the earth's scarce and possibly endangered capabilities of the earth in the interest of avoiding their over-exploitation and to foster actively a policy whereby citizens benefit from opportunities to live a fuller life. This means adequate facilities for leisure activities, as well as easily accessible information about voluntary and charity work. Although people's participation in such activities tend to be seen as pursuits which have no impact on the way society functions, these activities and the social

interaction which they support are an essential part of a full and complete life. They would also provide (paid) employment for those undertaking their coordination. Note also that if the financial basis of such facilities were dependent on funds provided by commercial entities we wouldn't be aiming for zero growth: Zero growth requires taxation on the use of natural resources, and standard income accounting requires that revenue to be spent on something in exchange. If there is to be support for social and cultural activities, the obvious source is the rental value of the finite earth as collected by governments in the form of taxation.

As to the unfairness of the current situation resulting in huge corporate profits we have argued elsewhere (Heesterman and Heesterman, 2013: 222*ff.*) that this is the almost inevitable result of the prevailing financial regime, where people need to find themselves a job at any wage. This cause of income inequality disappears by the addition of a citizen's income.

Concluding summary

The current trend of technology, robotics and automation, implies that a sustainable society must be one in which there is no open-ended economic growth of consumption. This can only be realized if the compulsion to work for money could be set aside. We have to assume that the will to achieve this is in evidence, otherwise the alternative could be a ruined earth. To eliminate the obligation to work for a financial reward, we need a citizen's income as well as facilities to lead a fulfilling life, financed out of taxation type charges on the use of the earth's natural resources and capabilities.

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