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Economic language and economy change: with implications for cyber-physical systemsAlan Cottey¹

Abstract The implementation of cyber-physical and similar systems depends on prevailing social and economic conditions. It is here argued that, if the effect of these technologies is to be benign, the current neo-liberal economy must change to a radically more cooperative model. In this paper, *economy change* means a thorough change to a qualitatively different kind of economy. It is contrasted with *economic change*, which is the kind of minor change usually considered in mainstream discourse. The importance of language is emphasised, including that of techno-optimism and that of economic conservatism. Problems of injustice, strife and ecological overload cannot be solved by conventional growth together with technical efficiency gains. Rather, a change is advocated from economics-as-usual to a broader concept, *oikonomia* (root - household management), which takes into account all that contributes to a good life, including what cannot be represented quantitatively. Some elements of such a broader economy (work, basic income, asset and income limits) are discussed. It is argued that the benefits of technology can be enhanced and the ills reduced in such an economy. This is discussed in the case of cyber-physical systems under the headings employment, security, standards and oligopoly, and energy efficiency. The paper concludes that such systems, and similar technological developments, cannot resolve the problems of sustainability within an economy-as-usual model. If, however, there is the will to create a cooperative and sustainable economy, technology can contribute significantly to the resolution of present problems.

Keywords: Economic language | Economy Change | Cyber Physical Systems | Industry 4.0 | Industrie 4.0 | Fourth Industrial Revolution

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Abstract The implementation of cyber-physical and similar systems depends on prevailing social and economic conditions. It is here argued that, if the effect of these technologies is to be benign, the current neo-liberal economy must change to a radically more cooperative model. In this paper, *economy change* means a thorough change to a qualitatively different kind of economy. It is contrasted with *economic change*, which is the kind of minor change usually considered in mainstream discourse. The importance of language is emphasised, including that of techno-optimism and that of economic conservatism. Problems of injustice, strife and ecological overload cannot be solved by conventional growth together with technical efficiency gains. Rather, a change is advocated from economics-as-usual to a broader concept, *oikonomia* (root - household management), which takes into account all that contributes to a good life, including what cannot be represented quantitatively. Some elements of such a broader economy (work, basic income, asset and income limits) are discussed. It is argued that the benefits of technology can be enhanced and the ills reduced in such an economy. This is discussed in the case of cyber-physical systems under the headings employment, security, standards and oligopoly, and energy efficiency. The paper concludes that such systems, and similar technological developments, cannot resolve the problems of sustainability within an economy-as-usual model. If, however, there is the will to create a cooperative and sustainable economy, technology can contribute significantly to the resolution of present problems.

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1 Introduction

Only within a broad setting is it possible to examine adequately the relationship between cyber-physical systems (CPS) and economic systems. Currently, discussions and implementations of CPS assume a capitalist economy. Businesses and nation states externalise their costs. Inequality increases. The weak are in danger but the ruthless exploitation seen in the early stages of the first industrial revolution (Fielden 1969; Gaskell 1968) is no longer acceptable. A means of limiting unemployment and indigence has been devised, namely economic growth. This device is fundamental to the maintenance of a degree of social stability. Consequently, there is a conviction that economic growth is necessary. Yet human economic activity cannot grow beyond physical and ecological planetary boundaries. An answer to this objection is needed. The usual response is to place faith in technology. The argument is that economic growth can continue and the needed economic activity can be switched to benign forms, such as carbon neutral energy production. The problem with this argument is that it has been in place for half a century and the result (with, say, ten year smoothing) is unbroken growth which has already surpassed a sustainable level. Technical efficiency gains (which are real, substantial and valuable) are outstripped by economic growth. This appears to be an inherent feature of the existing economic model.

Our current failure to take best advantage of modern technology and avoid the disadvantages is not confined to the problems associated with economic growth. Increased efficiency of time management has served only to make us feel busier and more stressed. We do indeed feel this as individuals but the source of the problem is the current economy, which has taken on a life of its own. This life-form prioritises commerce, and, partly by using a crafted language, elicits the loyalty of individuals, beyond what is in their own interest.

The manner in which CPS are being developed, and will be developed, is connected with the nature of the ambient economy. Currently, there is a mismatch between enthusiasm for technological change (Howell 2016; Schwab 2016) and caution about economic change (Ackerman and Stanton 2013; Oxfam 2016; Stern 2006; Stern 2009). Orthodox economists and leaders in business and government generally give inadequate attention to the profound changes already underway in the earth's climate and ecology. In this paper it is argued that change in the domain of economics is needed which is of the same order as the profound and rapid changes in technology, climate and ecology.

Industry 4.0 (or Industrie 4.0), Internet of Things, Cyber-Physical Systems, and some similar terms have, in only a few years, become widely used in connection with the future of manufacturing. Sometimes they are introduced casually - mere buzzwords. In the present paper, we are not especially concerned with variations of usage, nor with differences between these terms. It is enough for our purpose that these terms point to something that is important and is already underway, namely the close integration of IT with physical products. This integration starts at the beginning and continues throughout the full cycle of use, disposal and replacement. That is, from ideas and assessments, through design, testing, manufacture, marketing, sales, distribution, use, maintenance, product feedback, and recycling to design of the next generation. A product will commonly contain computer chip(s) and it may communicate with its environment, via the internet, throughout its life. Such an integrated cycle for a particular product is a cyber-physical system. Manufacturing in this manner, as a whole, is currently known as Industry 4.0. (Briefly, Industry 1.0 is characterised by mechanisms, steam power and the factory system, 2.0 by electricity, and 3.0 by IT.) The extension of the internet to embrace, worldwide, physical products as well as information, is the Internet of Things. Some of these novel, and indeed playful, terms will no doubt be superseded but the practice that they represent will likely be more durable - *if it is introduced in parallel with certain necessary economic and cultural changes*, which will be discussed in this paper.

2 Language

This paper deals with the mismatch, mentioned in the Introduction, between techno-optimism and economic conservatism, a mismatch that is a common feature of discussions of CPS, etc. A first step in addressing this problem is to examine the words and phrases used – and those not used. Those used are within a frame and those not used are outside it (Matthews and Matthews 2014). A frame draws attention to the picture within and away from what lies beyond. This is valuable if a concentrated focus on the picture is desirable. But what if something problematic lies beyond? Perhaps one blots out signals, through uncritical enthusiasm for a project. If one's attention eventually does move outside, there is a change in one's perception of what matters most, in some cases a rapid switch. The relevance of framing for questions about economic growth is examined in section 2.3.

2.1 Techno-Optimism

Much of the current discourse about emerging or prospective technologies is enthusiastic. The benefits are emphasised definitely. The problems are acknowledged but most often only as potentials. For example, the strapline of *Welcome to the Fourth Industrial Revolution* (Schwab 2016) reads "Technological innovations are fuelling momentous change throughout the world, generating great benefits and challenges, in equal measure." At first sight, this appears to be even-handed, especially with the appended "equal measure". On closer examination we may note, however, that a counterpoise to *benefits* might be *costs* and a counterpoise to *challenges* might be *opportunities*. (Schwab does however at the end of the Introductory section write symmetrically of "challenges and opportunities".) A closely similar asymmetry appears near the beginning of an article entitled *Talking 'bout a Revolution* (Howell 2016) "new technologies ... create potential peril as well as huge promise". Thus Howell claims a real, and indeed huge, promise but the peril is only potential. The kind of bias exemplified here is easily missed. A more salient asymmetry would not be accepted by author, editor or reader. Each such example is, by itself, of minimal significance but an alert reading of the whole of many such texts shows that the pictures presented are within a frame which contains a message foregrounding bold optimism about new technology. The message is apparently balanced by warnings but these are more likely to use weasel words, such as 'challenges'.

2.2 Economic conservatism

The world is in a dire cultural and ecological situation, characterised by ecological crisis (Barder 2016), environmental destruction (Worldwatch Institute 2017; Intergovernmental Panel on Climate Change 2017), human population increase (United Nations Population Fund 2016), insatiable consumerism (Barber 2008; Brown 2002), rising inequality (Battersby et al 2012; Collins 2012; Dorling 2014; Kroll and Dolan 2016; Pizzigati 2004), and horrific strife (United Nations Environment Programme 2017). These problems are interlocked (Beddington 2009) and are possibly connected with recent counterproductive political trends (Giroux 2016).

Nearly all economic discourse - that of professional economists, of political, administrative and business leaders, of the media and of the public - is conservative. It avoids or obscures the ecological, environmental and social problems. There is however a relatively small amount of contrary discourse. It comes from non-economists or from a small number of heterodox economists. Their critiques and the defensive response from orthodox economists will be taken up later in this paper.

The conservatism of professional economists and the mass media is reflected in the language of the public conduct of economic affairs. This language is technical, obfuscating and distracts from what is really needed, which is a critical examination of the values of the neo-liberal trend of the last half-century (de Angelis 2007). A core value of orthodox economics is economic growth, which evokes irrational devotion and respect. In a word, it is a fetish (Hamilton 2004). Why are so many intelligent and generally knowledgeable people blind to the patent dangers of continued economic growth? An answer is here proposed, based on an interpretation of the historical development of industrialism.

In the early stages of the first industrial revolution horrific conditions were imposed on workers (Fielden 1969, first published 1836; Gaskell 1968, first published 1836). To the simple cruelty of those conditions is added the shameful irony that rapidly increased productivity did not improve the workers' already poor conditions. The benefits of the new technologies went initially to owners of capital (Avery 2016). At certain times, when the needed conditions are all present, new technologies are introduced quickly. They confer advantages to some but are severely disruptive of social arrangements which have adapted over a long prior period of time. During, roughly, the last three quarters of the 19th century and the first three of the 20th, social reforms spread the benefits of technology more widely in the leading industrialised countries. The atrocious working and living conditions of the early period came to be generally recognised, in these countries, to be an affront to these cultures' self-respect. During this long period - approximately one and a half centuries - productivity continued to increase, albeit irregularly. The increases of productivity could have permitted everyone (in the industrialised countries and eventually everywhere) to have a decent life with good working conditions. In fact, the worst working and living conditions were ameliorated slowly, just enough to contain unrest of the poorest sections of society. Most of the benefits of the increase of productive ability went to the owners of property

(private capital in all forms). These twin aims - serving the interest of property owners and of those with little property - can be achieved by economic growth that starts from a low baseline.

For the last half century or so, the planetary limits to growth have however gradually become more apparent. Those limits - in the form of climate change, ocean acidification, desertification, loss of tropical forests, human overpopulation, city air pollution, and more - have now become obvious to all prepared to see what is there. Many, however, have so much invested in the status quo (education, training, expertise, status, employment, apparent prosperity) that they ignore or even deny the reality - continued growth is not possible.

2.2.1 Environmentalism, backlash and accommodation

In the late 1960s and the 1970s, a new kind of grassroots environmentalism arose in prosperous industrialised countries, with emphasis on reducing harm, consumption and waste (Carson 1963; O'Riordan 1976; Peterson del Mar 2012). Lengthy campaigns led, after the usual legislative time-lags, to significant improvements. Notable among these were the phasing out of the use of leaded petrol (Tsai and Hatfield 2011) and the 1985 Montreal agreement on emissions that depleted ozone in the upper atmosphere (Metz et al 2005).

This period was however brief and followed by "backlash and accommodation", the title of a section, pp 75 - 79, of Peterson del Mar (2012), when "pro-business politics made a strong comeback across the western world" (ibid p 75). A notable backlash was provoked by the path-breaking study *The Limits to Growth* (Meadows et al 1972). A virulent reaction came soon after publication from Wilfred Beckerman in a published professorial inaugural lecture (Beckerman 1972) "it seemed to me that the Meadows/Club of Rome document was such a brazen, impudent piece of nonsense that nobody could possibly take it seriously". In the forty-odd years since then this book has generated a great deal of comment and the discussion shows no sign of abating (pp 17 - 18 of AtKisson 2011). Especially since the publication of *The Limits to Growth* there has been a strong polarisation between orthodox economics, which dominates business, government and education, and a relatively small number of heterodox economists together with more numerous economic outsiders who place ecology change and climate change centre-stage.

The overall result has been a paradoxical and generally confused period, continuing to the present, eloquently described in several parts of Peterson del Mar's book, including the ironic penultimate sentence of the main text (p 98) "Loving nature and pushing the planet to the brink of catastrophe have been, more often than not, compatible." So far from rising to the challenge of climate change and ecology change, discourse about economic change has, in some respects, become more conservative over the last half century. As of the end of 2016 the confusion appears to be intensifying, prompting Henry Giroux (2016) to refer to an age of normalised ignorance.

2.3 Frames

The frame metaphor is especially apt when the subject is economics as generally understood in the culture that has become globally dominant. Discourse in the public arena, and among most professional economists, is largely about details of the picture within the frame. It is often limited to the numerical values of such quantifications as inflation rate or unemployment level: should there be an attempt to change an inflation rate by a small amount? shall a tax threshold be slightly changed? is the rate of economic growth about right, or too high, or too low? The quantities concerned distract from important qualitative questions, such as 'what counts as work?'

There has in recent decades been a significant amount of questioning that is outside this frame but most of it has come from non-economists or from a small number of heterodox economists. One memorable challenge to the usual framing of discourse about economic growth is attributed to the economist Kenneth Boulding, before the US Congress in 1973. He stated that anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist. This aphorism is entertaining and brings attention to a real issue but only as a caricature. There is no reason to think that any economist believes literally that exponential growth can go on forever in a finite world. The less amusing but more constructive questions are

- why do those with economic power (plutocrats, large institutions, political leaders and advisors) act and speak as if a rapid rate of economic growth for the foreseeable future is desirable and even vital for the well-being of all?

- why do most people accept the actions and speech of that same group?

It is suggested here that a significant part of the answer is the power of framing. Inside the frame are familiar icons - established ideas of the benefits of business-as-usual; of wealth and a model of its creation; of democracy, education, work; of deserving and undeserving poor; of the inviolability of property; of the role of the state. These icons usually offer small adjustments as answers to the serious economic and environmental problems of our times. It is easy to be mesmerised by the content of the frame, and fail to consider whether a succession of incremental changes is solving those problems or only putting off a harsh reckoning (Athanasίου 1997). The present paper may be considered an attempt to reframe economic language.

2.4 Sustainability

The language commonly used in the discourse of sustainability recognises, of course, that there is a problem with economic growth of the historic kind. It often expects much of efficiency gains, for example, permitting increased energy consumption with greatly reduced greenhouse gas emissions (Yang and Yu 2015; Weizsäcker, Lovins and Lovins 1997). Another paper (Gabriel and Pessl 2016), *Industry 4.0 and Sustainability Impacts*, does address issues of work and ecological consequences in a more balanced way. Its ideas about these consequences, and how to deal with them, assume, mainly by default, that the present neo-liberal economy will continue. The need, even inevitability, of fundamental economic change (economy change) is not recognised. Thus, for example, their section on Sustainability Impacts opens "Basically, the main objective of Industry 4.0 is to strengthen and expand the long-term competitiveness of the company ..."

2.5 Language change

The boundaries of public discourse about economics are largely set by orthodox economists and political, administrative and business leaders. The language used frequently has several or even most of the following characteristics - short-sighted, narrow, conservative, technical, mystifying, euphemistic. Terms which occur in popular contexts with little or no explanation

include - arbitrage, CDOs (collateralised debt obligations), CDS (credit default swap), deleveraging, derivative, eurobond, Federal Reserve, G7, G8, G20, hedge, investment bank, junk bond, leverage, Libor, liquidity, MTM (mark-to-market), monetary policy, naked short selling, OECD, options, Ponzi scheme, prime rate, private equity fund, PFI, QE (quantitative easing), rating agency, recapitalisation, repo, reserve currency, securitisation, short, swap, TARP (troubled asset relief program), Tobin tax, toxic debt. Such terms have a place in specialists' discourse but they are spoken and written in popular media in ways that betray a lack of desire to inform as accurately and fully as possible. As the science communicator James Gingell (2015) writes "Whether it's discussion of debt, or the argument for austerity, it's hard to find good economics communication, where the language is rinsed free of jargon." Two representative examples from the UK are:

- even a populist newspaper, the Daily Mail, has on a single day such terms as global equity strategist, business outsourcer, FTSE SmallCap index, VCT, AIM-listed (Mail Online 2016);
- and a more intellectual mass circulation newspaper, The Guardian (2016), has in the language of orthodox economics, in its National News (not Financial) section, two full pages on economic aspects of Brexit. The same issue of the newspaper does however also carry an essay (Burkeman 2016) on the shortcomings of time management.

Despite these unpromising characteristics, this language is accepted and repeated in the 'quality mass media' and even by critics. Yet when opponents adopt the language of their antagonists, they handicap themselves severely. They may have a good case but find they have lost the debate and for reasons they do not understand. It is, for example, easy but dangerous to accept the common usage *earn* when one really wants to be discussing *income*.

Language creates and is created by culture and is continually on the move (Danesi 2016). Sometimes it gets stuck but then stresses build up and after a while there are rapid shifts. In the period of main interest for this paper, post World War II, economic discourse has become more technical but different changes have taken place in several in other registers. Some of these changes are surprising, even shocking, from the earlier perspective. Remarkable changes have occurred, as testified by many examples: Coarse intensifiers are used much more widely. Language about sex and sexuality is more direct. A challenging lexicon of superstars' surnames (many through the reach of global sports) is accepted. Fanciful

neologisms in popular entertainment are widespread. New communication technologies have brought new words, expressions and styles. Of special interest for the argument of the present paper is the phrase *climate change*, which has penetrated public discourse rapidly and deeply, and has a notably high public profile. Thus, while economic discourse has indeed become more technical, this trend need not be considered permanent.

3 Economy change

No modest change from current economics comes near to addressing the current environmental, ecological and social problems. The case is here made for the use of the phrase *economy change* and its distinction from *economic change*. The latter means change of an economic nature, usually no more than a tweak, such as a small change of the balance between 'control of money supply' and 'tax and spend'. Economy change, in contrast, means a radical change to a qualitatively different kind of economy. In particular, it means a change which rejects the assumptions of neo-liberal economics that have been in the ascendant for about half a century. Thinking about alternatives to economy-as-usual requires a larger canvas than that of, for example, Industry 1.0 to Industry 4.0. Economics can no longer be restricted to what can be measured. A broader interpretation as *oikonomia* (from household management) is necessary. When this is used, the advantages and disadvantages of many qualitatively different economies can be considered.

The current tendency to look only within a small frame, displaying economics-as-usual, misses a bigger picture but stepping back and really seeing what is in the bigger picture is not as simple as it might seem. The mass media and dominant discourse exert a continuous pull in to the small picture. But if one does manage to study the landscape, a notable feature of the small picture becomes visible - it is dominated by measurement. Almost everything is commensurable, with monetary value being the means of measurement. And outside the inner frame one can see many elements of *oikonomia* that are absent in the smaller picture. Prominent are kinds of work that are constructive - often the most necessary work - but in economics-as-usual are undervalued or even not counted at all. Much of this work is done by women; much of it is people caring for each other (Mies and Bennholdt-Thomsen 1999). Caring for oneself is also work (Cottey 2013). What, after all, is more necessary and useful than caring for oneself and others? This change of perspective demands a radical re-

assessment of the place of the economics-as-usual kinds of income (remuneration, profits, inheritance) in the oikonomia. These remarks are not designing a new kind of economy or wishing for its existence. They are describing reality. It is far different from the economy as understood in the current narrow, monetised sense. The first step is to recognise all that is in the bigger picture.

Alternative economies do exist at the present time. A significant example is the micro-economy of a family that is not specially money oriented. An ethos of love, cooperation, sharing and support may prevail. This can be asserted without romanticising, for it has also to be noted that such conditions sometimes do not prevail, or else prevail sporadically.

Cooperation of a similar kind sometimes exists also in larger groups such as extended families or neighbourhoods. In larger areas, such as districts, much cooperation also occurs, even if practised with an ambivalent spirit, manifested in griping about local government. In quantitative formal economics, the reality of such cooperative activity is not recognised and the fruits cannot be measured. An overview of the studies and ideas of Elinor Ostrom and colleagues on the insufficiently recognised role of cooperation in economics (in the broad sense) may be found in Wall (2014). Buen Vivir, Degrowth and Ecological Swaraj (radical ecological democracy) are described by Kothari, Demaria and Acosto (2014). Eighteen case studies of community-based wildlife and ecosystem management in South Asia are reported in Kothari, Pathak and Vania (2000).

Several methods exist for recovering the broad meaning of economics from the sieve of economics-as-usual. The sieve separates what is important for capitalism and applies complex rules to produce precise numbers. This precision is however achieved only by letting go all that cannot be quantified with accuracy, or at least given a claim of accuracy. Some of the recovery methods attempt to establish broader concepts that can be very roughly measured or estimated; and possibly combined, by a rather subjective weighting, into a single index. The inputs to such estimates may include asking people to assess or describe their subjective sense of well-being. An account of numerous broader methods may be found in section 3.5 Measuring Welfare and Well-Being of Costanza (2015). Other initiatives to study and communicate economics in the broader sense of well-being find even semi-quantitative methods too restrictive and instead rely mainly on analysing personal narratives (Belton 2014). Beyond the immediate neighbourhood of the small frame we see economies that have been marginalised by today's economics-as-usual but still exist on a small scale. Intentional

communities, while embedded in economics-as-usual, continue to find significantly different ways of practicing their internal oikonomia. In another area we see the historical economies of cultures untouched by capitalism. Gift economies (Graeber 2012; Hyde 1979) and economies based on cooperation can help us see more than is presented within the small frame. Current assumptions, mostly unexamined, about property can, in an historical context, be seen to be far from inevitable (Garnsey 2007).

If we adopt a broader historical and intellectual viewpoint, ideas going beyond mere economic change become easier to consider. It is useful bear in mind that new technologies have had a transformative effect on human economies, not merely since the so-called industrial revolution but for many millennia (pp 2 - 8 of Brynjolfsson and McAfee 2014). So far from the current neoliberal economy being a contribution to the "the end of history" (Fukuyama 1992), the rapidly changing environment of life on earth means that economy change *of some kind* is something to be expected. We do not know what kind of change may occur in the coming years and decades but we may formulate a crucial question thus - Can humanity meet the current challenges of rapid change with intelligent thought and civilised behaviour, or will we descend into a vortex of strife and destruction? An assessment of the likelihoods of these two developments is not necessary, for even if the chances of the former should seem to be small they are worth aspiring to and working for.

It is here suggested that there is one broad and basic aspiration whose achievement would go a long way towards turning civilisation away from its destructive course. That aspiration is to give reality - and not, as at present, mere lip-service - to the basic principle that *all humans have a right to the basic necessities of a civilised life*. Achieving a reality of this kind will involve developments of an 'economy change' character. It is unnecessary and indeed unwise to attempt an exhaustive list of such developments. Instead, three developments will be described briefly which are considered important and achievable (though far from assured). They are considered culturally practicable from the argument that rapid adaptation to rapid environmental changes does sometimes occur (again, far from assured). They are considered technically practicable in that humanity has long possessed technologies adequate to deliver the basic principle, with unjust economies having been a major impediment. The three 'economy change' developments advocated here concern work, basic income, and asset and income limits. Fuller descriptions are given in Cottey (2013). Modern technology can help to make changes like these entirely practical from a functional point of view. The greater

challenges are social and political and the final section (5) will consider the imagination and will needed to divert our culture from its current destructive course.

3.1 Work

Here, the word 'work', in an economic sense, will mean any systematic activity useful in creating and sustaining a good life; or, in other words, work is that which contributes to the well-being of the self or other people. A consequence of this understanding of work is that caring for oneself and for others is included and is indeed perhaps the primary and principal form of work. The concept remains an economic one but only if economics is interpreted in its broader sense of *oikonomia*. It is however very different from the economics-as-usual concept of work, which is closely associated with paid employment (which includes that of employees and the self-employed). In business-as-usual thinking, many who contribute greatly to real well-being are said not to be working. They do not contribute to the usual economic indicators - they are 'economically inactive'. In the case of those who do work in the sense of being employed, there is a weak correlation between their work and the useful activity indicated above. Often the work is not very useful or may even be harmful. This applies to a large amount of the work which is directed against competitors. It also applies to work done in order to maintain a high rate of economic growth.

The amount of work *of the conventional kind* (remunerated work) that is required of people is fairly small, being that left over when unnecessary and harmful work is eliminated and when an appropriate level of delegation to machines and IT is in place. The *total* amount of work needed to change human society from its present condition to a just and sustainable condition will however not be small, since a great deal of caring and solidarity will be counted, even when not remunerated. Also, in the challenging conditions of today and the foreseeable future, much re-imagining, discussion and experimentation will be required and this, according to the above notion of useful work, also counts. The worries of some in earlier times that there would be too little to occupy people and provide fulfilment remain unfounded.

3.2 Basic income

The idea that every person should be awarded an unconditional basic income (BI) has had proponents for a long time (Ackerman, Alstott and van Parijs 2006; Atkinson 1995; Citizen's Income Trust 2016; Henley 2017; Raventós 2007; Skidelsky 2016). Roberts (1982) proposed a basic income model in connection with the problem of automation and unemployment. BI means that everyone, from birth till death, should be eligible for, and should receive as of right unless they wish to forego it, an income sufficient to allow them access to the necessities of a dignified life. The income depends on a person's basic needs but not on whether they obtain other income. It is often the case that a nation-state takes responsibility for making available basic or higher levels of certain such rights, such as clean air and water, education and health. Other necessities, such as clothing, shelter and food, are commonly not available in this way but are bought by individuals. For this they need pecuniary income. It is, in today's economies, possible for some to have insufficient income to provide even a basic decent life. In such economies there is normally some kind of 'safety net' system, so that the poor are not starved to death. Such systems are, with possibly a few exceptions, harsh and demeaning (Lavery and Loach 2016). BI avoids the injustices and inefficiencies of such 'last resort' systems by providing a modest income for everyone. The great majority of people in a jurisdiction are motivated to gain income beyond the basic level. The state obtains the funds for the BI payments from taxes of various kinds but BI is below any income tax threshold.

3.3 Asset and income limits

It is widely noted (see for example Battersby et al 2012; Collins 2012; Collins 2016; Dorling 2014) that the gap between rich and poor individuals, after decreasing in the middle part of the last century, has been increasing for about half a century. So far from trickling down, as one justification of extreme inequality has it, riches trickle up. The richest take advantage of complex financial operations and thereby multiply assets and avoid taxes. The current extreme concentration of assets in few hands is harmful. The essential problem concerns money and the very feature that makes it such a brilliant invention, namely that it is convertible into other assets to an almost unlimited degree. If you are rich enough you can, with few qualifications, do as you please. 'Asset and income limits' (AIL) proposes some language, concepts and methods which address the problem of concentration (Cotter 2000; Cotter 2013). Some features of this approach are :-

* Careful attention is given to the usages of terms like income, earnings, wages, assets, wealth.

* Taking away a person's lawfully gained income by taxation is unpopular and this is perfectly understandable. Within a given jurisdiction it would be more logical and indeed more acceptable (once the idea is understood) to set maxima to a person's income and assets. A jurisdiction would then rely less on personal income tax and more on other forms of taxation, sales tax and corporation tax for example.

* AIL fits well with basic income (section 3.2). The ratios between basic and maximum incomes should, in view of the world's twin problems of poverty and over-consumption, be quite modest.

* Many people have a strong desire to excel, in some way or another, and everyone needs respect and recognition. An economy incorporating AIL and BI needs ways of satisfying these desires and needs. Such ways must be benign. That is, they must be such that human activity as a whole does not compromise justice, or harm the environment or the earth's ecology. It is argued in the fuller expositions that such benign rewards exist (honours, prizes, celebrity, services ...) and would be highly valued. The benign rewards must not be saleable.

* Temporal fluctuations of income can be smoothed if each person has a personal bank account plus a holding account (Cottey 2000; Cottey 2013).

4 Cyber-physical systems

The full implementations of Industry 4.0 and CPS are futuristic ideas (Howell 2016; Schwab 2016) but significant steps have already been taken, as described for example by Khaitan, McCalley and Liu (2015) on smart electrical power grids, by Majhi, Patra and Dahl (2015) on public utilities in India, and by Lee, Bagheri and Kao (2014) on industrial informatics.

It is argued in the present paper that future economy change *of some kind* is inevitable. Dystopian scenarios are all too easy to imagine. At the time of writing (end of 2016 and beginning of 2017) there is much anxious talk of political and social change and uncertainty. For those who find it difficult to see hopeful signs, two references can be recommended. Hans Rosling, in a Nature interview (Maxmen 2016) challenges widespread negative preconceptions about global health; and Steven Pinker (2011) in *The Better Angels of Our Nature* suggests (p xxi) that "today we may be living in the most peaceable era in our species'

existence". Both of these theses have their critics. In the present paper, however, the point of view taken is that those arguments have merit as needed counters to a widespread pessimism and fatalism about our future prospects. Gradual improvement of human culture is worth thinking about and working for, even though tribulations may be expected to continue.

It is considered here that economy change guided by intelligent thought and a will to reform is a useful object of study. This section will therefore consider the roles of CPS as part of an economic ambiance that is not dominated by current business-as-usual. No detailed scenario will be offered but rather an impressionist picture of a world in which the neo-liberal ideology and practice of the past four decades or so has gone out of fashion. Such swings do occur. Climate change, ecology change and social and political strife may hasten economy change. That change *may* be towards an economy with some of the characteristics discussed in this paper - more recognition of human cooperation and less emphasis on individualism; the good life associated more with conservation and less with consumption; conflicts resolved more by peaceful, empathetic methods and less by violence. In such a culture specific ideas like those mentioned in sections 3.1 to 3.3 (Work; Basic Income; Asset and Income Limits) would be recognised as propositions worth considering and testing. The following sub-sections discuss briefly some of the challenges and opportunities presented by CPS to an economy of this broad kind.

4.1 Employment

An aspect of cyber-physical systems that has attracted much attention, and some alarm, is the impact on employment. Such systems are large and very complex and, especially for the sake of security, must be carefully designed and operated. This requires a relatively small number of highly skilled designers and managers. The systems will then produce, distribute, operate and maintain goods and services, and perform needed recycling, needing only a small amount of human labour. We have been in similar places before. In the early 19th century Luddites (Jones 2012) protested the rapid disruption of their livelihood (hand weaving). In 1890 William Morris published *News from Nowhere* (Wilmer 1998), a utopian romance of a future cooperative society in which the small amount of necessary work was treated as a healthful pleasure.

In the 1950s and 1960s there was fear of mass unemployment but the alternative vision of a leisure society survived, with computers and robots doing all the tedious and dangerous work, and humans sharing what remains in reduced hours of work. Morris' attitude was taken further in Bob Black's 1985 essay *The Abolition of Work* (pp 17 - 33 of Black, no date) in which coercive work is considered a social evil.

To date, neither the mass unemployment nor the leisure society have occurred. See Akst (2013) for a review of the 1960s anxiety about automation. Near the end of his essay, Akst writes "Perhaps the biggest lesson we can learn from the midcentury thinkers who worried about automation is that while there is cause for concern, there is no other way but forward. Like trade, automation makes us better off collectively by making some of us worse off. So the focus of our concern should be on those injured by the robots".

David Autor (2015) has asked *Why Are There Still So Many Jobs?* and his answer (p 5) is "Automation does indeed substitute for labor - as it is typically intended to do. However, automation also complements labor, raises output in ways that lead to higher demand for labor, and interacts with adjustments in labor supply." Autor's paper does not use the language of growth and planetary boundaries have no place. This allows him (p 28) to reiterate in 2015 a 1966 view of Herbert Simon, that "the world's problems in this generation and the next are problems of scarcity". The present paper takes a radically different view, namely that, insofar as the 'growth solution' of the last half century was a solution at all, it cannot continue in any similar way into the future on a generation time-scale.

If, as argued in section 3, economy change is to be expected, it makes sense to try to steer such change intelligently, to maximise the positive potential and to minimise the painful effects of the kind that have historically been visited upon the vulnerable. In the case of the new information and control technologies, of which CPS is an important special case, there is an opportunity to reduce drastically the amount and the drudgery of what is conventionally understood by work.

4.2 Security

The importance and difficulty of security issues is indicated by the fact that five of the thirteen chapters of *Cyber Physical Systems Approach to Smart Electric Power Grid*

(Khaitan, McCalley and Liu 2015) are devoted to this subject. A further widely publicised security issue, albeit less serious, is DDoS (Distributed Denial-of-Service) attack. *Internet-Enabled Devices Fuel Rising Number of Ddos Attacks* (SMBWorld Asia Editors 2014) and *Irish Lottery Site and Ticket Machines Hit by Ddos Attack* (BBC News 2016) are two of many reports on this. The internet-enabled devices referred to include consumer goods in large numbers and their users have a low level of awareness of the security issues posed. A more serious cyber security problem, about which there is heightened current concern, is inter-state cyber warfare. Harrison Dinniss (2012) writes (p2) "The national security strategies of states such as the United States and the United Kingdom now reflect the central role of cyber security in their planning".

The point of interest for the present paper is that there can be no long-term purely technical solutions to security issues with new technology. There is a continual 'skills race' between robbers and cops. Economy change, represented in this paper as an opportunity as well as a threat, *might* be towards a more cooperative and constructive society, perhaps with features like those mentioned in section 3. Cyber-crime is hardly likely to become a negligible problem but it could be more marginal. In such a society, a greater (but still limited) level of trust would be possible and the extreme complexity of CPS would be less problematic.

4.3 Standards and oligopoly

In technology, standards for measurement and production, and agreed definitions are fundamental to the high level of comfort and achievement (of the advantaged and average classes) of humanity. For example, the speed and depth of penetration of telecommunications and IT are due in part to the fact that the IT world accepted the internet protocol suite (TCP/IP) in a civilised manner by discussion and not by warlike struggle between states or corporations. The standards that underpin the worldwide web were agreed rapidly in a similar manner. In contrast, some other IT developments, the 'browser wars' for example, were marked by discord. Concerning another development, the smart grid, Mathias Uslar writes, on page 3 of Uslar, Rohjans and Trefke J (2012), "an appropriate Information Communication and Technologies (ICT) infrastructure is needed to control the ... grid and gather relevant data. Furthermore, the use of standards within this future infrastructure is indispensable ... in order to reach a proper interoperability level."

The point of view of the present paper is that the last half-century's economic system, neo-liberalism, has embraced individualism and competition and rejected state regulation uncritically. The apparent successes and a degree of stability of this period are due to economic growth and are a loan from the future. Nevertheless, a complete reversal, a total rejection of competition is not realistic and not advocated. The problem is to find the best balance between cooperation and competition and to find that balance in a nuanced way, that is, to find an appropriate balance in each application or system.

The relevance of these remarks is that cyber-physical systems depend strongly on standardisation and there is a danger that monopolistic or oligopolistic organisations (whether commercial or national) may achieve dominance that is not in the wider human interest. Here again is a reason for working to nudge the inevitable economy change in the direction of cooperation.

4.4 Energy efficiency

A significant fraction of the work done to date on CPS is done to improve energy efficiency, especially of the use of electrical energy (Khaitan, McCalley and Liu 2015; Majhi, Patra and Dahl 2015). In the first of these two references, the chapter by Jiang et al (2015) describes the application of CPS ideas to the use of one-day weather forecasting to mitigate the problem of intermittency of solar and wind energy generation.

Such developments have the potential to be valuable in helping everyone, worldwide, to live a dignified and fulfilling life. Nevertheless, such gains of energy efficiency can only be real if they are used in a changed economy whose oikonomic values are modest and generous, not presumptuous and selfish. Efficiency gains need to contribute to a net decrease, globally, of harmful emissions, especially of greenhouse gases, *and* eliminate poverty. This is a tall order and an appropriate kind of economy change is vital to success (Trainer 2007).

5 Visions

Human culture works on the basis of ideas, expectations and plans. The near future plans are quite specific and as the time horizon expands the emphasis changes to expectations and to ideas. In every case adaptations are made as time proceeds and reality emerges. In this article, it is argued that economics-as-usual is not viable, except on a short time-scale. Ideas and plans which assume the contrary are unrealistic. In this situation, it makes sense to attempt a balance between general ideas and specific plans appropriate to the time-scale concerned. We do not know how long economics-as-usual will continue. It has experienced many crises and recoveries (business cycles). None of these has been so radical an upheaval as the first industrial revolution. The interval between crashes that are significant but not terminal varies from less than a decade to several decades. In this paper it is argued that economics-as-usual, in which the business cycle is, in the long run, merely a minor price to be paid, cannot last much longer. It depends on rapid growth and has already surpassed planetary boundaries, particularly in respect of climate change. Even allowing for its noted resilience it is hard to see how economics-as-usual can continue for many more decades.

With the benefit of half a century's hindsight we see that realising the technical promise of automation was the easy part. The needed profound economy change (not mere economic change) was far more challenging and was seen off by backlash and accommodation. Now, when many social and economic problems beset humanity, hope is needed but technological optimism is not enough. Visions of a new kind of economy are needed. Elements of such visions include - making use of abundance where it exists (knowledge, technical capacity); avoiding unnecessary and harmful activity; developing trust in our ability to manage ourselves and our inventions to the benefit of all. Within a business-as-usual economy, cyber-physical systems and similar technological developments cannot resolve the basic problems of sustainability; if, however, there is the *social will*, technology can contribute significantly to the creation and quality of a cooperative and sustainable economy.

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