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Science fiction and innovation: A response[☆]

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ABSTRACT

Daniele Archibugi's use of the film *Blade Runner* to discuss future prospects for techno-economic paradigm change is considered in relation to several questions. Is science fiction a literature of prediction and, if not, what role might it have in developing insights about possible futures? Is the current economic malaise predominantly due to a shortcoming of technological opportunity or to a fiscal paradox and political decisions about how to deal with this paradox? Might the present day equivalent for techno-economic paradigm change be more about the innovations necessary to rebuild or retrofit our existing technologies than about producing new growth sectors?

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1. Introduction

Daniele Archibugi's article takes the film 'Blade Runner' as a foil for discussing how Schumpeterian economics may be related to epochal changes in the direction of long-term economic growth. He explores whether an exhaustion of technological opportunities is part of the explanation of the financial crisis of 2008 and the continuing shortcomings in the recovery from it, and, ultimately, what opportunities exist for future economic growth and technological innovation. This is a heavy burden for a film, the central theme of which is the equally weighty question of what it means to be human. In the film, this theme is developed using artificial human beings or 'replicants,' who are violently 'retired' (somewhat gratuitously since they are past their sell-by date and programmed to self-destruct anyway) by the film's anti-hero who develops divided loyalties. The film offers rich visual detail of an imagined future but a rather sparse account of how that future came to be. As Archibugi observes, while the film is set in a distant future, it recapitulates features of our contemporary world such as the physical stratification of wealth and social class, the continuation of war (although conflicts seem to have been relocated to certain 'off world colonies'), the migration of people, and, perhaps, the consequences of climate change. Thus, the film offers elements of both discontinuity and

continuity which Archibugi argues are characteristic of Schumpeterian growth processes.

1.1. Epochal changes in the direction of long-term economic growth – part I

In considering epochal technological change, Archibugi focusses our attention on two groups of technologies that feature in the film – information and communication technology (ICT) and biotechnology. He observes that since the film was produced, our accomplishments have outstripped the film's vision with regard to the first, but barely progressed against the second. As technological prediction, therefore, the film is not very helpful (the predictive value of science fiction will be considered further in the conclusion). Archibugi seeks to explain this disjunction in the rate of progress in these two groups of technologies since the film's original release in 1982 by recourse to technological uncertainty and technological opportunity, and the complementary role of investment and entrepreneurship. Biotechnology's technological potential, and the opportunities to transform it into a general purpose technology that might be used to grow plant or animal 'replicant' tissues for our food, fibres for our clothing, or even, as in the film, companions and soldiers, have not (as yet) materialised. Instead, as Archibugi observes, most of the realisation of biotechnology's potential is in a relatively small segment of the pharmaceutical industry. In this industry, instead of creating giant new firms such as the film's Tyrell Corporation, biotechnology has most often augmented the size of incumbents and clearly has not achieved 'creative destruction' that portends epochal technological change. A large part of the poten-

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tial of ICT has materialised in contrast, with corresponding inflows of investment and outflows in the form of diffusion and adaptation which imbue everyday objects with increasing information processing and display capabilities – be they phones, cars, home appliances, and so forth. In terms of entrepreneurship, if we take the film to represent a vision of a few decades into our future, the man in the high castle of the film may be more akin to an aging Elon Musk, rather than Eldon Tyrell, the film's mastermind of replicant production.

1.2. The 2008 crisis and the recovery

The deeper issue that Archibugi addresses is the contributory role of technological opportunities to the slow recovery from the 2008 crisis experienced to date. Crises of the magnitude of 2008 have many sources. The leading technology of our era, ICTs, certainly contributed to the instabilities and volatility that provided the tinder for this conflagration. ICTs, in combination with other technologies such as containerised shipping, accelerated global merchandise and service trade, enlarged the accompanying financial flows at risk of financial instability. ICTs, in combination with a neoliberal faith in the economic rationality of markets, helped to create and to gain acceptance for financial instruments that subsequently became toxic banking assets. Institutions meant to regulate risk-taking, again under the influence of neoliberal ideology, demonstrated their incapacity to adjust to this changing landscape. More positively, the same landscape conditions also supported a huge expansion in market access for rapidly growing developing countries and with it the resulting transformation of millions of peoples' lives, generally for the better but, in some cases, for the worse.

The widespread belief that innovation will restore economic growth to the robust levels of an earlier era is, indeed, worthy of critical examination. Archibugi portrays the engine of this restoration as being fuelled by expectations and this leads him to the question of where opportunities are opening up to fuel those expectations. In other words, with positive expectations, investment that would restore jobs and boost final demand should follow. Contrasting with this entrepreneurial explanation, (Mazzucato and Perez, 2015) argue that surges of technological innovation are fuelled by government investments that demonstrate the feasibility of new market opportunities – with private sector entrepreneurship following the lead of the entrepreneurial state (Mazzucato, 2015). For Perez and Mazzucato, the absence of bold 'productive' government investments is the source of both the weak aggregate demand and the weak levels of entrepreneurial initiative underlying the current malaise. A third, fiscal policy oriented approach is that it is the insufficiency of aggregate demand (for both investment and consumption) that requires state action at a level resembling America's New Deal or the Marshall Plan for the reconstruction of Europe. The persistence of low long-term interest rates offers the opportunity for the state to borrow in order to make productive investments – not only in innovation, but also in aging infrastructures. Unfortunately, public debt has become a toxic political issue under several narratives including that based on the notion of inter-generational equity. Yet, as Summers has observed in the United States context, future generations might actually prefer owing the debt to inheriting an infrastructure with an enormous deferred maintenance bill (Summers, 2016). Similar opportunities may exist in other rich nations, while the infrastructure investments required to 'modernise' in middle and low income countries offer enormous opportunities for both investment and innovation. These positions recapitulate the persistent debate regarding the origins of technological opportunity – whether it can be manufactured by stimulating demand, whether it arises naturally from research investment or whether it requires the particular visionary

skills embodied in entrepreneurs who also have a fanatical commitment to opening up and exploiting these opportunities. In order to determine what policy or mix of policies might be of value, evidence about the current levels of expectations and technological opportunity is required.

1.3. Epochal changes in the direction of long-term economic growth – part II

In commenting on current global economic conditions, Archibugi offers a pessimistic short-term outlook comparable to, and citing, Robert Gordon's recent case for pessimism (Gordon, 2016). In short, Gordon's argument in the United States context is that productivity-improving innovations beginning in the late 19th century and extending to the first decades of the 20th century have become a spent force. In Gordon's view, the late 20th century innovations related to the ICT revolution may similarly have exerted most of their impact already, with no new technologies of comparable effect on the horizon. Archibugi is rather more optimistic than Gordon, predicting growth through a consolidation and a deepening of the current paradigm. This, however, seems to be matter of faith rather than of evidence, since the primary support for his optimism is a Delphi-like study from McKinsey which assesses the main medium-term opportunities that will stem from ICT applications including robotics. His own work (Archibugi et al., 2013a,b) on expectations suggests a more pessimistic prospect. This stems from the continued business hesitancy in Europe to invest in R&D in order to bring about the consolidation and deepening of the existing (ICT) paradigm (or anything else for that matter). Europe, however, has been afflicted by its own overdue structural crisis arising from the institution of a common currency without correspondingly forceful regulatory institutions to govern the effects of economic disparities within the European Union.¹ This crisis is ongoing with European banks continuing to have a propensity to hold assets rather than to make loans.² Outside Europe, the processes of modernisation and adaptation to globalisation are, in fact, sustaining growth rates in some countries (e.g. China) that would, twenty years ago, have seemed astonishing and very acceptable in others (e.g. India). It is also remarkable that the nearly universal slower pace of inflation means that the real gains from growth are larger. The story on expectations, therefore, is mixed – perhaps weak at the traditional frontier where new and large opportunities would be helpful, but stronger behind the frontier where catching up processes are still vigorous.

The elephant in the room, however, is the seemingly inexorable march towards a set of crises – catastrophic climate change, spiralling inequality, and an ever-expanding movement of people fleeing war or poverty. These emerging issues challenge the prospects for innovation investments continuing as usual and may be exerting strong effects on expectations shaping long-term business investment. The threat of climate change means that most of the world's agricultural and industrial systems, including transport and housing, need a massive retrofit to avoid catastrophic changes in the earth's environment. This requires an accelerated depreciation of many fixed assets. Barring science fiction type solutions such as Blade Runner's emigration to 'off world colonies', this will require major investments, a means to make returns on those investments (which will probably involve significant tampering with market prices) and innovations that will improve the return on, and reduce

¹ Moreover, the EU faces important constraints stemming from its limited fiscal position relative to its Member States (see Dabrowski, 2010) for a useful overview).

² Although bank lending generally is not a principal source of R&D investment, its absence means that fixed investments and working capital levels compete with R&D for company cash flows.

the scale of, those investments to manageable proportions. Despite the recent Paris accord, the direction of the market interventions needed to achieve what is now a matter of common agreement remains uncertain; hence, expectations about returns on investments in a more sustainable future are low.

ICTs are implicated in inequality to the extent that they have reduced the substantial number of middle-income human information processors, also called middle managers, and made it possible to outsource or automate many low-skill jobs and change the skills needed for some medium-skill jobs, preventing competition for labour from raising wages and salaries. Few governments have addressed the challenge of building new skills or even of determining what skills will be relevant in the new economy implied not only by ICT, but also by sustainability. The emphasis on STEM (science, technology, engineering and mathematics) subjects clearly neglects the scale and scope of the creative industries, which constitute one of the more rapidly growing sectors needed to sustain higher long-term growth rates. Beyond this, new types of jobs involving community-based production and services that allow the accumulation of skills will be needed to re-integrate Europe's youth into the labour force and to provide opportunities for employment in localised production in other countries. Experimentation with the most effective forms of organisation for such jobs is a new form of research and development which needs protected (and subsidised) spaces in order to take root.

ICTs are even implicated in the migration of human populations, since they provide a window on life elsewhere and an immediate capacity to communicate with those who have already emigrated and who, in turn, are able to send remittances to those left behind. Emigration is not a first choice for most people, even in difficult circumstances. However, it can become the only choice if community-based development or urban employment are absent. Although it has always been in the interest of the richer countries to provide development assistance, the case for doing so now seems even stronger than in the past.

The direction of markets, including markets for innovation, is shaped not only by supply-side innovation but also by the aggregation of individual consumer demand which, despite a small contingent of 'green consumers' (and voters), seems intent on continuing business as usual. This creates inertia in the systems in place. A different pattern of collective action than the aggregation of individual preferences (i.e. the market) or the often democratically deadlocked state seems necessary to steer economies in both rich and poor countries along a different path. This is where the potential for transformative innovation exists. What is needed is the entrepreneurial imagination to conceive of a way to tap this potential.

1.4. Return to science fiction?

Other features of the Blade Runner film that Archibugi does not discuss point to a world in which dramatic change has come to Los Angeles – the ever present rain, the billboards for emigration to the 'off world colonies', and the apparent success of this campaign in depopulating the city (and perhaps the world?). It is possible that space may become a frontier – the solar system offers bounteous energy and material resources, all consumable without atmospheric consequences so long as we are able to get there without destroying what is left of our fragile environment. As science fiction readers and most others are very aware, however, it is a frontier beyond our reach with current technology. This redoubles the need for assuring that the 'home planet' remains habitable rather than being treated, as our present economic incentives and regulatory practices tend to do, as an unlimited consumable resource.

If science fiction is taken as prediction, it is more often dystopian than utopian. With disturbing frequency, the future earths of science fiction authors are depopulated through some *deus ex machina* of megadeath – whether through nuclear incineration, disease or, with increasing regularity, the replacement of human beings with machines, the latter being tested in prototype in the film Archibugi cites as the next step in imagination, Transcendence. Transcendence explores the idea of 'uploading' human consciousness and, to its credit, again raises the question of whether the entity thus created remains human. This vision may be preferable to that presented in another recent film, The Road, where civilisation has been reduced quite literally to ashes and the quality of human life to the struggle for survival. Transcendence is within the realm imagined by Richard Brautigan: 'I like to think (it has to be!) of a cybernetic ecology, where we are free of our labors, and joined back to nature, returned to our mammal, brothers and sisters, and all watched over by machines of loving grace.' (Brautigan, 1968:117) Of course, the machines might not exercise even this modicum of care, as Transcendence suggests and as envisaged more viscerally in the various incarnations of the Terminator films and TV series. The dystopian qualities of science fiction have always served to identify dangers inherent in the path that we are currently following.

Rather than prediction, science fiction is thus a genre which offers imaginaries of a more hopeful future (as in Star Trek, for example) as well as confrontations with the more disturbing elements of the world in which we live. It is less a guide to the future than a recognition that the road on which we travel into the future has many branches. It is less a storehouse of innovations waiting to be brought forth than it is an imagination of what consequences current innovations might potentially have for human experience. Perhaps it is then significant that some of the younger authors (e.g. Paolo Bacigalupi) as well as older ones (e.g. Margaret Atwood or Kim Stanley Robinson) are increasingly imagining an environmentally degraded world with drowned cities, blighted crops, and hopeless people. These visions are more common in print than in film, where audiences are likely to prefer a more palatable vision of the future. The recent film Interstellar is an exception that combines both optimistic and pessimistic elements. These contemporary science fiction visions of ecological disaster join the historical evocations of nuclear and biological war, overpopulation, meteor strikes, superhumans and machines vying to replace humans, and other horrors that remind us that we face a bleak future if we do not succeed in making the innovations necessary to sustain life on earth. In making these innovations, we may indeed address both the question of human survival and the need to discover a new paradigm that can serve as the basis for future economic growth.

Archibugi suggests that the current ICT techno-economic paradigm may have run its course, with another paradigm (such as bio-technology) emerging in the wings to carry on the process of economic growth as we have experienced it in the last seventy years (the Post World War II era) or the various periods that can be associated with the industrial revolution (ranging from two centuries in the case of England to decades for rapidly emerging economies such as South Korea). Against these time scales, it is premature to conclude that the ICT paradigm has run its course and particularly hazardous to do so in the aftermath of the most profound economic crisis in the industrialised countries since the Great Depression of the 1930s. The next steps in the ICT paradigm involve the extension of robotics, ICT assisted restructuring of the cycles of production, use and re-use rather than the discarding of artefacts, the advent of the new approaches to artificial intelligence, and the continued development of the computational and communication infrastructure. These are all opportunities for a resurgence of growth in output and productivity in the current paradigm. This 'business as usual' perspective, however, misses the point that we have reached a time when a more fundamental rethinking of the

nature of mass production and consumption is required. This is essential in order to avoid the catastrophic outcomes that, without mitigation, the current system will bring in the course of its further extension to a larger share of the world's population (Schot, 2016). This 'rethinking' called by various names – transition, transformation or renovation – involves innovations in new areas of technology (materials, energy generation, and biotechnology) as well as 'retrofitting' of current technological systems in a similar way, but at larger scale, than was accomplished as the result of the petroleum crises of the 1970s. Drawing back from the brink of environmental catastrophe will require major investment and through that investment, the creation of jobs and growth on a similar scale to the onset of a new techno-economic paradigm. In effect, what is needed is the sort of mobilisation previously undertaken in preparation for war. To engage in this scale of mobilisation without substituting command and control processes for markets and entrepreneurial initiative is the challenge facing the next generation of citizens and policymakers.

References

- Archibugi, D., Filippetti, A., Frenz, M., 2013a. *Economic crisis and innovation: is destruction prevailing over accumulation?*. Res. Policy 42 (3), 303–314.
- Archibugi, D., Filippetti, A., Frenz, M., 2013b. *The impact of the economic crisis on innovation: evidence from Europe*. Technol. Forecast. Soc. Change 80 (7), 1247–1260.
- Brautigan, R., 1968. *All Watched Over by Machines of Loving Grace. The Pill Versus The Springhill Mine Disaster*. Houghton Mifflin, Boston, MA.
- Dabrowski, M., 2010. *The global financial crisis: lessons for European integration*. Econ. Syst. 34 (1), 38–54.
- Gordon, R.J., 2016. *The Rise and Fall of American Growth: The U.S. Standard of Living Since the Civil War*. Princeton University Press, Princeton, NJ.
- Mazzucato, M., Perez, C., 2015. *Innovation as Growth Policy: The Challenge for Europe. The Triple Challenge for Europe: Economic Development, Climate Change, and Governance*. In: Fagerberg, J., Laestadius, S., Martin, B.R. (Eds.). Oxford University Press, Oxford, pp. 229–264.
- Mazzucato, M., 2015. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. Public Affairs (Perseus), New York.
- Schot, J., 2016. *Confronting the second deep transition through the historical imagination*. Technol. Cult. 57 (April (2)), 445–456.
- Summers, L.H., 2016. *The age of secular stagnation*. Foreign Aff. 95 (2), 2–9.