# PROMETHEUS critical studies in innovation

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# PROMETHEUS critical studies in innovation

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#### 221 Editorial

# Editorial

*Prometheus* has never had any truck with the citation counts and journal impact factors which are supposed to reveal which are the very best journals and, by implication, the very best papers with the very best authors. Nor has *Prometheus* any time for h-indices and the myriad of other statistical convolution purporting to identify academic excellence. They have no reputable purpose and are damaging to scholarly endeavour, particularly as they can all be gamed. Competitive higher education expects academics to game the indicators of academic performance, and the greater the gaming, the more yet further gaming is required to remain competitive. Do any academics write without an eye to performance measures?

Albert Einstein did; Einstein was no gamer. The Web of Science database lists the 147 papers he published between 1901 and 1955, the year of his death. For his 147 papers, Einstein received 1,564 citations during his lifetime. That's an average of about ten citations per paper, not at all impressive by modern standards. Such a performance would not have brought Einstein tenure and promotion these days. But then Einstein would not have been appointable to any academic job at all these days; his doctoral thesis was just twenty-six pages long. He could easily have padded that out. And his objection to the peer review of his papers was hardly likely to endear him to journal editors. Most disappointing of all, though, is that only twenty-seven of his paltry 1,564 lifetime citations are self citations! Einstein was not really trying.

Robert Merton's Matthew Effect – 'for unto every one that hath shall be given' – refers to how academic publishing favours the famous. The famous need not even be alive. Einstein is famously cited for his declaration that 'Not everything that can be counted counts and not everything that counts can be counted.' True enough, but Einstein said no such thing; William Cameron did in *Informal Sociology*, published in 1963. Since his death, Einstein's publishing performance has improved considerably, easily compensating for his failure to game when he was alive. As of 2019, Einstein had amassed a total of 28,404 citations to what he may – or may not – have written, giving him a very respectable h-index of 56 and increasing his employability no end.

These thoughts are inspired by the release of the first data on the impact *Prometheus* is having under its new publisher. Much has happened since Pluto Journals became our publisher at the start of 2020. *Prometheus* has become an open access journal, its contents freely available to everyone. It should come as no surprise that citation of a journal's papers rises when its papers are freely available; as a hybrid subscription journal, *Prometheus* papers that were open access (in other words, available freely to non-subscribers) were always in greatest demand.

But what metrics should the open access world use? The traditional subscription model of academic publishing has increasingly accommodated gaming, reducing the purpose of academic publishing to little more than scoring. To be sure, basic problems remain for open access to solve. For example, the article processing charge imposed by some open access publishers transfers payment from subscribers to authors and helps make plain that authors rather than readers are now the customers of the academic publishing industry. This reality is even more evident in the industry's predatory publishing sector, where an academic paper no longer has to be readable to be countable.

More adventurous forms of open access (such as that being developed by Pluto Journals) hope to attract support from the many funding organizations whose missions include the broadest possible dissemination and communication of the latest scientific knowledge. One problem here is that old research and old citations boost journal impact factors much more than new. Not unreasonably, these organizations require evidence of public value from their funding of open access journals. While a plethora of usage data is available, it is not immediately clear which of this is useful.

JSTOR, the distributor of Pluto Journals, has just issued its first usage figures for *Prometheus*. These reveal that most of our users are in higher education or in a category almost as large and

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labelled 'unknown'. Our users would seem to be in either the US or the UK. Their usage in the first six months of 2021 is 973% greater than it was in the whole of 2020, which is as gratifying as it is baffling. New usage measures will probably be adopted from 2022, when our current arrangement with JSTOR ends. Altmetrics, counting the mention of academic papers in social media (in tweets, blogs, Facebook pages, YouTube, news media, whatever), offers the ultimate in mass usage measurement. It picks up public recognition of a paper's existence, but has nothing to say about its quality or even whether it has been read. And numbers of likes and followers would seem to be particularly susceptible to gaming. Altmetrics will probably work wonders for Einstein's publication performance in a world which finds the face familiar, but stops well short of understanding why  $E = mc^2$ .

This issue starts with Peter Senker's *magnum opus*; he insists it will be his last. Senker provides a Polanyian analysis of the environmental damage resulting from economic activities. Such activities cause environmental damage which could make much survival difficult for human beings, for other animals, and for plants and insects. Senker, from the science policy research unit at the University of Sussex, is no optimist; our natural environment really is in grave danger. Nor does he see much hope of salvation in orthodox economics. Indeed, faith in markets has done much to cause the problems we now desperately seek to solve. Neoliberal solutions are unlikely to be effective, and policies restricted to climate change alone are particularly unlikely to be adequate. Policies which take a holistic approach, considering all the important impacts of human economic activity on the environment, have much better prospects. Research and analysis are urgently required in the design and implementation of policies sufficiently effective to reduce the damage to the environment caused by human economic activities.

The authors of the next paper are statisticians and economists, hopefully of a different stripe from the sort lambasted by Senker. Luke Hendrickson, David Taylor, Lyndon Ang, Kay Cao, Thai Nguyen and Franklin Soriano hale from the government sector in Canberra and look – in huge detail – at the impact of persistent innovation on Australian firm growth. Their work reveals that short-term persistent innovators (particularly young SMEs) significantly outgrow their less persistent and non-innovator counterparts in terms of sales, value added, employment and profit growth. Persistent innovators are more likely to be high-growth firms and to introduce multiple types of particularly novel innovation. The authors recommend broad-based innovation policies to support successive waves of the high- growth firms that will help to sustain economic and employment growth in Australia. Numerous figures and tables containing the paper's supporting evidence are to be found on the *Prometheus* website (http:// www.prometheusjournal.co.uk/).

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From persistent innovation to frugal innovation, the subject of our third paper. These are innovations that are far from the latest whizz-bang gadgetry required by boys wanting more toys. These are innovations that excel in providing value for money, acceptable quality, scalability and marketability. They would seem to be especially appropriate for developing economies. The paper's authors, Avinash Shivdas, Saswata Barpanda, Soumya Sivakumar and Ram Bishu, variously from Amrita Vishwa Vidyapeetham in Kerala, Marymount University in Virginia and the University of Nebraska, are less concerned about the impact of frugal innovation than with defining what it is. They conclude that frugal innovation is very far from second- class innovation, innovation on the cheap. Frugal innovation is efficient innovation with nothing wasted on bells and whistles. It presents managers with considerable challenges: encouraging innovation is hard enough, but at the same time discouraging fancy innovation may be harder still.

As ever, we conclude with our book review section, seven reviews of some of the latest and most intriguing works on innovation.

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Stuart Macdonald General editor

# **RESEARCH PAPER**

# Restricting environmental damage resulting from economic activities: a Polanyian analysis

# Peter Senker

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#### ABSTRACT

Economic activities continue to cause considerable environmental damage. The extent of damage could be such that the environment in and around our planet will be affected, making survival difficult for human beings, for other animals, and for plants and insects. The paper reviews economic developments from the nineteenth century and how these have been influenced by orthodox economic theories. Markets are central to orthodox economics, and to policies which have been implemented recently to restrict global warming. Since the 1980s, policies based on orthodox economics and neoliberalism have been widely implemented by governments, and also by international organizations. Such policies are evaluated and found to be seriously inadequate. Studies of environmental implications of the development of two major sectors of the world economy follow. Policies which are concerned only to restrain climate change are unlikely to be adequate by themselves. Policies which take a holistic approach to considering all the important impacts of human economic activity on the environment have greater prospects of success. The paper concludes by suggesting research and analysis be undertaken urgently to assist with the design and implementation of more effective policies to reduce the damage to the environment caused by human economic activities.

#### Introduction

The environment of our planet could be affected by human economic activities to an extent which will make survival difficult – for human beings, for other animals and for plants and insects. Such damage results from global warming; it includes reduction in the diversity of animal and plant life able to survive, damage to earth and air quality resulting from the extraction of enormous quantities and varieties of minerals – in addition to coal, oil and natural gas fuels which are subsequently burned – and the dumping of waste products. The historical and economic roots of most aspects of the problem of human economic activities detrimental to the environment are common. Accordingly, an historical perspective is adopted in the attempt to identify these common roots.

Orthodox classical and neo-classical economists have based much of their analysis on the basis that land and labour behave as commodities. At many places in this paper it is emphasized that, for economic theories to reflect reality, aspects of both human activities and nature have to be taken into account. This cannot be done if land and labour are treated as if they are commodities. In 1944, Polanyi identified this fundamental error and suggested that it had infected orthodox economics. Thus, orthodox economics provides inadequate foundations on which to build strategies for reducing the extremely serious environmental problems which confront humankind.

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Roots of the environmental problems we now face derive largely from the industrial revolution which started in England late in the eighteenth century. There was also a rapid rise in the world population of human beings, from about 1 billion in 1800 to about 1.5 billion in 1900 and to about 7.7 billion in 2019 (Roser, 2019). From the nineteenth century, industrial and agricultural changes developed rapidly, first in England and subsequently spreading to and developing further – in Germany, the United States and the rest of the world, in unequal patterns. This was reflected in very uneven patterns of distribution of the multiple resulting economic benefits and environmental impacts – both geographically and between various sections of the populations in each country.

A central assumption of orthodox economics from Adam Smith onwards has been the inevitable and central role of markets in economic activity. Local markets have existed for a very long time indeed. But markets only became highly significant in economic development during and after the industrial revolution (Polanyi, 2001, pp.45–6). Late in the nineteenth century, the need to transport and distribute ever-growing quantities and varieties of factory-produced goods over ever-increasing distances resulted in markets gaining strategic importance.

Markets are central to orthodox economics, and to current policies which have been implemented to restrict global warming. These policies are evaluated from the perspective of the extent to which they appear to be successful in restricting damage caused to the environment. This is followed by brief studies of the environmental implications of the development of two major sectors of the world economy: land transport, and agriculture and food. This paper concludes with preliminary suggestions about some broad areas in which empirical research and analysis need to be undertaken, with the aim of forming a sound basis for designing policies which will be effective in reducing the damage to the environment caused by human economic activities.

#### **Products made in factories**

Schumpeter's 'avalanche of consumer goods' (see below) was a consequence of revolutions in production and products combined with numerous other important changes. These included rapid technological development, first in means of transport and then in means of communication, which resulted in enormous increases in the productivity and extent of first transport and later communications, concomitant with considerable reductions in their costs. According to Schumpeter (1954, p.67):

The capitalist engine is first and last an engine of mass production which unavoidably means also production for the masses . . . It is the cheap cloth, the cheap cotton and rayon fabric, boots, motorcars and so on that are the typical achievements of capitalist production. The capitalist achievement does not typically consist in providing more silk stockings for queens but in bringing them within the reach of factory girls in return for steadily decreasing amounts of effort.

Continual revolution in production methods and in product availability have resulted in 'an avalanche of consumer goods . . . the capitalist process . . . by virtue of its mechanism, progressively raises the standard of life of the masses' (Schumpeter, 1954, p.68).

At first, transport on land consisted largely of people walking, riding on horses and other animals, and using animals to carry people and/or goods on land and to draw carriages. In addition, boats and ships carried people and goods on rivers and seas. In England from the mid-seventeenth century onwards, ever-increasing resources were devoted to expansion of river transport and to construction of new roads and bridges. The first canals were built in the 1750s. By 1780, many major industrial centres were linked by navigable waterways and solid roads (Landes, 1969, pp.46–7). The development and use of steam engines as pumps in coal mines and then, from about 1830 onwards, the use of the Watt steam engine for transport by railway trains led to enormous increases in the mining and combustion of fossil fuel. The initial burst of railway construction in Britain was followed by huge investment in railways in the 1840s. Between 1830 and 1900, railways contributed very substantially to the creation of ever-increasing and diverse markets for an ever-widening

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range of factory-produced goods. Between 1840 and 1913, railways were built in many countries, and a very large proportion of the rapid increase in traffic in Europe, North America and Britain was carried by them (Freeman and Louça, 2001, pp.190–6).

The widespread use of electricity – first produced mainly by burning coal – began towards the end of the nineteenth century. Revolutions in communications, including radio and television followed by computing and social media, started later. And production of automobiles, invented in the late nineteenth century, began to expand rapidly after the introduction of the Ford Model T in the United States in 1908. The Model T epitomized Schumpeter's revolution in production methods, which reduced the costs of production substantially so that each car could be sold in huge quantities at amazingly low prices. Such developments led to very rapid increases in the extraction and use of a changing mix of fossil fuels which aided the construction and use of a changing variety of products and services. To this was added growing household use of fossil fuels, first for domestic heating and then for air conditioning of homes for people and families with rising incomes (Landes, 1969, p.96; Dennis and Urry, 2009, p.32; Freeman and Louça, 2001, pp.188, 309–24; Zuboff, 2019, pp.29–30).

Traditional economics is wrong to assume that individuals have well-defined preferences and fully rational expectations and perceptions and that individuals know what they want. If this were so, there would be little scope for advertising. In reality, advertising can and does shape preferences (Stiglitz, 2012 pp.146–7). Towards the end of the nineteenth century, advertisements in newspapers began to be used to promote mass sales of newly developed factory-produced breakfast cereals in the United States (Lawrence, 2008, p.10). In the 1920s, after considerable controversy, radio became commercialized in the United States, with very few stations broadcasting numerous advertisements to huge audiences (Wu, 2017, pp.74–85). Television experienced a similar fate in the United States a few decades later: by 1957, television followed radio to become 'the creature, the servant, and indeed the prostitute of merchandising' (Walter Lippmann as quoted in Wu, 2017, pp.155–6). Radio and television have been followed by social media as cheap and effective ways of reaching huge audiences for advertising, first in the United States and subsequently in many other areas of the world. Thus, the worldwide pattern of excessive use of fossil fuels has not been created exclusively by consumer demand. It has also been stimulated greatly by extensive advertising and other means of promotion.

A general pattern of individualization of consumption of products, both by broadening their appeal and by varying details of their design, has been undertaken by companies to increase sales, especially since the beginning of the twentieth century. Promoting radios, televisions and mobile telephones successively to increase their appeal to specific types of business, and to individuals as well as to families, are other examples of this process. Social media have been extensively and very profitably developed in recent decades to market huge varieties of products and services to individuals.

By the twenty-first century, in contrast to the substantial benefits gained by millions of families and consumers, many such enormous developments had combined to result in substantial damage to the environment. Economic development has involved enormous quantities of fossil fuels, coal, then oil and natural gas being extracted from land and sea and then burned. This combustion has taken place in numerous rapidly growing economic activities, including construction of factories, use of many of the products made in those factories, transport of raw materials and components of those products, transport of people by water, road, rail and subsequently in the air; together with combustion to heat and – subsequently in relatively prosperous areas – also to cool people's homes, places of work and other buildings.

#### Polanyi's criticisms of laissez-faire and orthodox economics

The drive towards laissez-faire (abstention by governments from interfering in the workings of the free market) was designed to create a self-regulating economic system motivated by individual gain. But this implied a thoroughly distorted conception of life and society, based on assumptions

that markets are institutions which had arisen naturally in the course of history, and that for people to behave as traders in markets is also natural to human beings (Polanyi, 2001, pp.276–7).

Many nineteenth-century economists assumed that an economic system consisting of markets and under the sole control of market prices, and a human society based on such markets, would be the goal of all progress. Human beings' materialistic propensities would induce them to abide by economic rationality, and all contrary behaviour would be the consequence of outside interference. For example, in relation to work, 'economic man' would expect payment for his labour, would choose lesser effort rather than greater; and in business he would strive for profit (Polanyi, 2001, pp.257–8).

Polanyi defines a commodity as something that has been produced for sale on a market. According to his definition, land and labour are fictitious commodities because they are not originally produced to be sold on a market. Polanyi's book *The Great Transformation* makes it clear that economic theories based on considering land and labour as commodities are inevitably false. In reality, labour is only one of the activities of human beings and land is only one aspect of nature. Adler (2015, p.4) summarizes Polanyi's views about this concisely and accurately:

Unlike the equipment and intermediate goods that businesses find available in the marketplace, natural and human resources are not truly commodities – they are not produced for sale on the market. On the contrary, natural resources are given by nature, and human resources are nurtured by families and communities. They are 'fictitious' commodities, to use Polanyi's term: they are resources whose treatment as commodities contradicts the actual conditions of their production and exchange.

Polanyi considers that the social conditions created by the industrial revolution and its widespread introduction of factory production involved a 'veritable abyss of human degradation'. Large parts of the country 'were rapidly disappearing under the slack and scrap heaps vomiting forth from the satanic mills'. Ordinary people, especially workers – many of whom had lived previously in rural environments – had been 'dehumanized... crowded together in new places of desolation' in slums in the industrial towns of England. This was a catastrophe involving 'an avalanche of social dislocation' (Polanyi, 2001, pp.41–2).

In contrast, the analysis of the pioneering economist Adam Smith (e.g., in *The Wealth of Nations*, first published in 1776) could be based on observation only of economies before and during the period when he was writing. For several centuries, traditional products, such as wheat, wool, meat, beer had been supplied in horse-powered vehicles made by traditional methods in small quantities using traditional materials. Nevertheless, he also observes some new economic developments. For example, he is well aware of the significance of the division of labour in increasing productivity. Indeed, this is the subject of the first chapter of *The Wealth of Nations*, in which he reports his observations of the division of labour in pin-making (Smith, 2010, book 1, pp.4–11). He next introduces the concept of 'the invisible hand', suggesting that 'It is not from the benevolence of the butcher, the brewer or the baker that we expect our dinner, but from their regard to their own interest' (Smith, 1910, vol. 1, p.12). His rhetoric is magnificent in reaching the conclusion (expressed here in modern language) that self-interest combines with the division of labour to promote economic growth:

As every individual ... endeavours much as he can both to employ his capital in the support of domestic industry, and so to direct that industry that its produce may be of the greatest value; every individual necessarily labours to render the annual revenue of the society as great as he can... By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases led by an invisible hand to promote an end which was no part of his intention. (Smith, 1910, vol. 1, p.400)

Adam Smith assumes that the division of labour is primarily the consequence of the human 'propensity to truck, barter and exchange one thing for another' (Smith, 1910, vol. 1, pp.5–12). This may have been a reasonable assumption towards the end of the eighteenth century when *The Wealth* 

*of Nations* was being written. But the industrial revolution had barely begun by 1776 when *The Wealth of Nations* was first published. The number of factories in existence then was tiny, and Smith could not possibly have been aware of their future economic significance. Nevertheless, Adam Smith's observations, rather than his preaching, could have formed the basis for later economic analysis based on empirical observation.

Not, however, until 1944 did the first publication of Polanyi's *The Great Transformation* make it clear that the tendency to barter, on which Adam Smith relied heavily, has never been a tendency of human beings in economic activities (Polanyi, 2001, pp.45, 258). The significance of this criticism was later expanded by Guy Routh (1989), who diagnoses Adam Smith as having suffered from 'a curious conflict in beliefs'. While he preached that 'only government interference hindered the invisible hand from guiding mankind along the road to plenty', Adam Smith's often acute observations of how the economy actually works suggest that his fundamental beliefs were false. For example, many of those whom the 'invisible hand' should force to compete for the benefit of the public in practice often conspire to fleece the public (Routh, 1989, p.103). In his next chapter, titled 'From propaganda to dogma', Routh provides several examples in considerable detail of how Adam Smith's curious conflict in beliefs was continued and amplified by numerous subsequent classical and neo-classical economists (Routh, 1989, pp.104–7).

Polanyi observes that fossil fuels have existed for thousands of years below ground as part of the land and of nature; they were not created for the purpose of being bought or sold in markets. However, during the industrial revolution and subsequently, rapidly increasing quantities and types of fossil fuels were extracted, priced, sold in markets and subsequently burned. Polanyi argues that, without protections, 'nature would be reduced to its elements, neighborhoods and landscapes defiled, rivers polluted, military safety jeopardized, the power to produce food and raw materials destroyed' (Polanyi, 2001, p.76).

The development of mass production and the distribution of factory-produced products during the first half of the nineteenth century, together with mass marketing towards the end of the century, should have been observed and taken into account by later orthodox economists. They should have noticed that these rendered some of Adam Smith's assumptions invalid. By the end of the eighteenth century, laissez-faire, supported by numerous orthodox economists, had triumphed in Western Europe and the United States. Capitalists now had political power with which to promote their wealth (Routh, 1989, p.105). 'The spiritual blindness which made possible the general acquiescence in the horrors of the early factory system was, not a novelty, but the habit of a century' (Tawney, 1926, p.196).

By the time of the early factories, it was generally believed that a science had been discovered which put the laws governing man's world beyond any doubt. With compassion removed from their hearts prosperous people had become morally degraded, denying all responsibility for the welfare of their fellows. A society which had previously been influenced by Christianity had gradually been transformed into one dominated by the new secular religion of laissez-faire. Human solidarity was renounced 'in the name of the greatest happiness of the greatest number . . . the new creed was utterly materialistic and believed that all human problems could be resolved given an unlimited amount of material commodities (Polanyi, 2001, pp.42, 106–7, 143). As pointed out by Pigou (1951), 'Economics was consolidated into dogmas which provided blunt instruments with which to bludgeon at birth useful projects of social betterment'.

Moreover, even if an invisible hand had existed before the industrial revolution, it is difficult to see how there can possibly still be an invisible hand which can ensure that consumers are benefiting from the purchase of heavily promoted, factory-produced goods in the twenty-first century, goods specifically designed to increase the profits of the companies producing and marketing them. Blythman gives numerous very detailed examples of how the characteristics of a huge variety of mass-produced, processed food have been adapted and changed with the intention of increasing the profits of those producing and marketing these products. Such changes in characteristics can have severe adverse effects on consumer health (Blythman, 2015).

A central problem is that orthodox economists – first classical and subsequently neo-classical – persisted in developing their theories and analyses on the basis of false assumptions. Neo-classical economists devoted far too much attention to theoretical development, and far too little to observing the fundamental ways in which economies changed during the nineteenth century and subsequently. During the nineteenth century, economists should have observed the rapid and extensive changes in the path of economic development caused by the industrial revolution. They should also have observed new findings from research in such disciplines as economic history, anthropology, psychology and sociology, which had become increasingly relevant to the analysis of economic phenomena. Such observations could have helped neo-classical economists to realize that the theoretical structure which they were spending so much time and effort erecting and elaborating was built on unsound foundations.

#### Neoliberalism's influence on policy

*The Great Transformation* was first published by Polanyi in 1944, three years before neoliberalism came into existence. But it is necessary to consider neoliberalism briefly in this paper because, although most orthodox economists claim to reject neoliberalism, it now exerts substantial influence on many of those who make economic policy. The ideas behind neoliberalism were formed by a group of intellectuals – including Friedrich Hayek and Milton Friedman – who formed the Mont-Pélérin Society in 1947. Their ideas exerted little influence on economic policy until they began to be adopted by the governments of the United States and the United Kingdom in the 1970s and 1980s (Jones, 2012). Neoliberals do not advocate laissez-faire and are even less inclined to advocate restraints on corporate behaviour than neo-classical economists. They consider that governments should confine themselves to safeguarding individual and commercial liberty and strong property rights; that market mechanisms are the best way to organize all transactions involving goods and services; that free markets and free trade liberate the creative, entrepreneurial spirit which exists in human society; and that this freedom can lead to greater well-being and better allocation of resources (Thorsen, 2010, p.204).

But governments which now follow policy advice from the policymakers convinced of the benefits of neoliberalism by no means always follow coherent policies which accord with neoliberal advocacy of free markets and free trade. This is because there can be conflict between the neoliberal state's aim to create a society with an atmosphere favourable for business to work in and invest in, and at the same time to cope with needs to protect the environment and to protect workers' rights and quality of life. Harvey (2005, pp.70–1) observes that, in cases of conflict arising from 'treatment of labour and the environment as mere commodities', the neoliberal state assigns relatively low priority to labour's needs and environmental considerations. George (2015, pp.5, 123–31) goes further, suggesting that neoliberalism deters both national governments and international policymakers from even thinking about implementing tough legislation to restrain global warming.

Government reluctance to restrain global warming is exemplified in the persistence of huge government subsidies for fossil fuels throughout the world. Any government action that lowers the cost of fossil fuel energy by raising the price received by producers or lowering the price paid by consumers may be classified as a fossil fuel subsidy. Such subsidies are so huge, diverse and complex that it is impossible to get an accurate picture of their global scale and effects. The most conservative estimates are that these subsidies amount to less than 5% of global gross domestic product, but some estimates suggest that they amount to well over 5 trillion dollars – about 6.5% per cent of global GDP. It has been estimated that more than half of government fossil fuel subsidies are for oil products, with the rest split almost equally between natural gas and electricity. There are international agreements, in particular the United Nations Framework Convention on Climate Change Paris agreement (2015), which have set targets for emission reduction. But several countries with large emissions – such as Australia, Brazil and the United States – have either not signed up to these agreements or made very modest commitments to  $CO_2$  reduction. In principle, it is possible to conceive of international tariff policies which could contribute to emission reduction.

But so far climate agreements have made little reference to trade. Moreover, tariff reduction seems to have increased trade in carbon-intensive and environmentally destructive products, such as fossil fuels and timber, more than in environmental goods. Further, several governments have invoked the world trade organization settlement mechanisms to challenge policies designed to stimulate CO<sub>2</sub> emission reduction in China, India, Canada, EU member states and the US, on the grounds that both subsidies and offering domestic priorities for renewable energy violate the free trade principles to which they subscribe. Neoliberal policies of government unwillingness to intervene in the operation of markets are widely entrenched in policymakers' thinking, causing reluctance to promote legislation to reduce environmental damage, although neoliberal attitudes do not appear yet to have had any significant impact in terms of reducing fossil fuel subsidies: indeed, the international monetary fund anticipates that large fossil fuel subsidies are likely to continue (Dawar *et al.*, 2019, pp.5–14, 21–3; Coady *et al.*, 2019, pp.5, 29).

# Current policies intended to reduce global warming

Joseph Stiglitz, an eminent economist, contributed a foreword to the 2001 edition of Polanyi's *The Great Transformation*, in which he suggested that:

the issues and perspectives Polanyi raises have not lost their salience. Among his central theses are the ideas that self-regulating markets never work; their deficiencies, not only in their internal workings but also in their consequences (e.g., for the poor), are so great that government intervention becomes necessary; and that the pace of change is of central importance in determining these consequences. Polanyi's analysis makes it clear that popular doctrines of trickle-down economics – that all, including the poor, benefit from growth – have little historical support. (Stiglitz in Polanyi, 2001, p.vii)

However, subsequently Stiglitz – unlike Harvey (2005) – failed to indicate sufficient appreciation of some central features of Polanyi's analysis: that the treatment of labour and land as commodities in orthodox economic analysis contradicts the actual conditions of their production and exchange. In a recent paper, Stiglitz wrote:

if we 'ruin' this planet through an excessive emission of greenhouse gases, we cannot move to another. This means that from a social point of view we should be especially focusing on innovations that reduce emissions; but so far, without a carbon price, firms have little incentive to do this. (Stiglitz, 2017, p.631)

Accordingly, it is not surprising that, in accordance with such thinking, policies involving carbon markets and prices in the shape of emission trading systems have been recommended by economists and adopted in order to counter threats of climate change with the aim of reducing greenhouse gas emissions and protecting society. Indeed, such policies are encouraged by article 6 of the Paris climate agreement of the twenty-first conference of the parties of the United Nations framework convention on climate change (2015). In a recent paper, an eminent climate scientist, James Hansen, has supported such policies. He writes that climate science shows unambiguously that global fossil fuel emissions must decrease rapidly over the next few decades, if young people are to avoid climate calamities. 'Economists say that such a change is not only possible but makes economic sense, because economies are more efficient if subsidies are eliminated and externalities are included in prices' (Hansen, 2018, p.52). While few rational people would question Hansen's great expertise as a climate scientist, this latter statement must have been made on the basis of the advice of the economists Hansen consulted. That the economists did not take sufficient account of the enormous difficulties in measuring sufficiently consistently, accurately and reliably the huge number and variety of enormously complex externalities is not surprising. As we have seen, for more than three hundred years, economists - as in this case - generally advocate ineffective market

and price solutions in an attempt to solve society's problems in preference to regulation. This preference is reflected in the advice given to Hansen.

Similarly, the international carbon action partnership (ICAP) suggests that emission trading systems (ETSs) are already delivering cost-effective fossil fuel emission reductions in several sectors in numerous countries (ICAP, 2020). ETSs and other policies are not independent of each other; they interact in many ways (ICAP, 2020, p.5). Carbon markets, however, represent an expansion of markets that fails to address the underlying contradictions involved in the commodification of nature. Various types of market fundamentalism attempt to expand commodification, and to subject society and nature to market rules. Thus, a market-based problem gets a market-based solution. There is an abundance of evidence which supports the conclusion that 'further attempts to commodify carbon emissions through carbon markets also increase risks to society by preventing or delaying alternatives with the potential for transformative reductions in greenhouse gas emission. Extensive research on the effectiveness of the largest ETS in the world, the EU emissions trading system, concluded that it has been almost entirely ineffective in reducing emissions. Numerous environmental and economic justice groups have called for it to be abolished (Klein, 2014, p.225).

#### **Two sector studies**

Two short studies based on examination of empirical data are presented below. They are intended as a basis for preliminary assessment of how better to approach the design of environmental damage reduction policies. In addition to the combustion of fossil fuel used to facilitate production and/or use of numerous products and service, many types of metal are extracted from the earth to make components for a huge variety of manufactured products, from jewellery to semiconductor components. These aspects are only touched upon in this paper, but the first case study below (of the automobile industry) includes preliminary consideration of the environmental impact of mineral extraction. And the second case study (of agriculture and food) also includes preliminary consideration of some biodiversity aspects.

#### Sector study 1: land transportation – the automobile versus public transport

Between the 1840s and the 1880s, the development of railways was the principal factor in enormous and rapid growth in the number of horses in the narrow streets of large cities throughout the world. Huge numbers of horses and carts were needed to take goods from where they were produced to railway termini; to deliver goods from railway termini to their consumers, and also to transport rail passengers between homes, offices and railway stations. The horses used for such purposes were causing major pollution problems in cities and large towns, which represented a significant threat to human health and welfare. By the 1890s, cities were desperate to find a solution to these problems (Thompson, 1976; Morris, 2007).

A few years later, motor cars provided solutions to these severe problems. The development, mass production and mass marketing of extremely cheap and reliable petrol-driven motor cars in the United States stimulated the creation of the automobile society, first in the United States and then in the rest of the world. The Ford Model T was first produced in 1908. It incorporated some important principles of production engineering which were well established by then – in particular, standardization of design, and incorporation of precisely interchangeable component parts. Ford also incorporated a moving belt assembly line in the production process. These developments enabled Ford to produce Model Ts profitably at much lower prices than any car had previously been produced. Production of the Model T increased to over 350,000 in 1915.

But cars remained a luxury product in Britain for much longer than they did in the United States. In 1912, British production of motor vehicles was only about 5% of production in the United States (Savage, 1966, pp.92–7). By 1939 there were still only about 2 million cars in Britain compared with 27 million in the United States in 1940. Ford's methods of production had resulted in the ability to make cars which could be sold at a profit at very low prices,

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methods that were copied first in the United States and later in Britain and other countries (Savage, 1966, pp.92–7). Car production increased much faster in the United States than in Britain and other countries because other US companies copied Ford in adopting assembly line production more quickly than automobile producers in other countries. The domination of cars over public city transport was secured initially in the United States by car manufacturers and their component suppliers conspiring effectively to buy up and destroy competition from electrified buses and trams. Not until 1955 were these companies found guilty of the Sherman Anti-Trust Act, but by then car domination was firmly established and the fines the companies had to pay were very small. Car culture became dominant as an expression of the good life, most especially in America, but also throughout most of the rest of the world (Dennis and Urry, 2009, pp.35–7). This is reflected in enormous expenditure by most governments to support the use of cars. Dwight Eisenhower, a five-star general during the second world war, had been greatly impressed by the world's first superhighway system, the German reichsautobahn. After his election as president of the United States, Eisenhower pressed hard for a national system of superhighways to be built there. The interstate highway act was passed by Congress in 1956, and this project – the largest in the nation's history – was undertaken, building 46,000 miles of road at the cost of over \$130 billion dollars of federal government money (Schlosser, 2002, p.22).

When automobiles were introduced to cities, they represented enormous improvements in terms of pollution reduction (Jacobs, 1964, pp.356–7). Automobiles and lorries could get to places which railways could not reach and did jobs trains could not have done. Their potential for improved transport productivity and efficiency over the horses and buggies which they replaced was enormous. But each horse was replaced by too many automobiles, vans and lorries. The resulting traffic and parking congestion means that vehicles may move little faster than the horses they replaced.

More and more land goes into parking to accommodate the ever-increasing numbers of vehicles while they are idle... the more space that is provided for cars in cities, the greater becomes the need for use of cars, and hence for still more space for them. (Jacobs 1964, pp.363–5)

During the twentieth century, automobiles and trucks became the dominant mode of landbased transport for both people and goods. Indeed, automobiles and other vehicles driven by internal combustion engines provided unexpected solutions to the many problems of pollution and traffic congestion in cities caused by the use of horses. But within a few decades of their introduction, the rapid growth of human populations and automobile use in cities caused further, different problems in cities. There are now many millions of these vehicles throughout the world, each driven independently. Most governments encourage private car use and many have undertaken extremely large highway construction projects. In 2002, the average car user in the United States conducted 86% of journeys by car and on average, each adult travelled 13,500 miles by car annually. With the exception of Denmark and the Netherlands, private car ownership and use is increasing rapidly, especially in previously communist states, such as Poland. Similarly, car ownership is increasing in Africa and Asia, especially where there are population increases and industrial growth. China is now second only to the United States in car ownership (Dennis and Urry, 2009, pp.28–30, 44).

Unlike public transport vehicles (such as trains, trams, buses and taxis), most cars spend nearly all their time parked. In the minority of time they are travelling, they often cause considerable congestion, mainly in cities, but in rural areas also. The road space constructed for these vehicles covers an increasing proportion of total land area. Just as important, the availability of this highly flexible individual mode of transport has had important implications for town planning – and its neglect. Many supermarkets have been built in locations only easily accessible by car. Insufficient attention is paid to minimizing the need to travel by locating residential accommodation, work, shopping and recreational facilities in close proximity. Perhaps worst of all, in the United States – and increasingly in other countries, especially highly populated ones – over-dependence on automobiles is becoming increasingly destructive of water, air and land (Jacobs, 1972, p.117).

The use of automobiles requires the manufacture of a box, usually made of steel, but also including many other materials (such as rubber and plastic), together with the incorporation of electronic control equipment. This manufacture involves extensive mineral extraction around the world, with consequent pollution of land, water and air; it also causes disruption to communities previously living and working on the land from which the minerals are extracted. Major corporations are engaged in manufacturing cars; numerous other major corporations are engaged in the manufacture of the cars' components, and still other major corporations are engaged in extracting minerals – principally oil – and converting these minerals into fuel to power these cars. In developed countries, and increasingly in developing countries, cars are second only to housing as the most expensive item of individual consumption. The environmental impact of cars arises from extraction of the raw materials required for their manufacture, from the production process, the operation and maintenance of the vehicle, and from the construction and maintenance of roads. To make a typical car demands nearly a ton of metal, together with 90 kg of plastics, 45 kg of rubber and more than 8,000 kilowatt hours of energy. Car use also causes many human deaths and injuries through road accidents, and also health problems arising from air pollution (Dennis and Urry, 2009, pp.36, 45).

The total world car fleet was about 1 million in 1930. Eighty years later – by the middle of 2010 – it was about 1 billion, a thousand times greater. By 2019, it had grown further to about 1.3 billion. At present, the majority of the world's car fleet is still concentrated in rich countries. Principal growth is now expected in large poorer countries, such as China and India, where millions more people are expected to become sufficiently prosperous to buy and run cars. The world passenger car fleet is expected to grow much further, perhaps to about 1.8 billion by 2035. In 1930, there was about one car for 2,000 people worldwide. The proportion had increased to about one car for 50 people by the 1950s. By the first decade of the twenty-first century, this had grown to about one car for every eight people worldwide.

State funding of car manufacturing is immense throughout the world. Every car manufacturer in Europe has received subsidies for establishing car manufacturing plants from the governments of the country in which they are located. Similarly, new car manufacturing plants in Brazil, China and India benefit from substantial state subsidies. Nowhere are such huge subsidies offered for investments in public transport (Whitelegg and Haq, 2003, pp.286–7; Lindeman, 2018; Scalzaretto, 2019; Roser, 2019). It is widely believed that rapid growth in the production, sale and use of road vehicles is essential to meet people's needs for transport. Yet, governments must meet targets for reducing greenhouse gas emissions, to improve air quality in towns and cities and to satisfy the demands of consumers. As a consequence, many vehicle manufacturers are building hybrid and electric vehicles (hybrid vehicles are powered for part of their journeys by petrol motors and for part of their journeys by electricity from batteries).

More than one million electric cars were sold in 2017, and by 2019 there were about three million electric cars on the world's roads. At present, electric cars are high specification, top-of-therange vehicles offering consumers advantages in the relatively low cost of fuel in the electricity they consume. Customers may also reap some satisfaction from helping to mitigate global warming. Similarly, manufacturers of electric cars persuade governments to facilitate strategies to encourage electric car manufacture. The cost of the batteries used to power electric cars makes the car very expensive, though the cost of batteries is falling fast. By 2025, the price of an electrically powered car may be similar to that of a fossil fuel car. Ten years later, there could be one car for every five people on the world's roads (Eckart, 2017, Katwala, 2018; Coren, 2018, 2019).

China and Norway have been prominent in offering incentives, penalties and encouragement to stimulate shifts from fossil fuel cars to electric cars. China is the world's largest market for cars, representing nearly a third of world car sales. Production of cars in China, for both home and export markets, has been growing in recent years. Nevertheless, the Chinese total home market for cars was lower in 2019 than in 2018, and is expected to be still lower in 2020. But the proportion of electric cars bought in China is much higher than in most other countries, at over 4.5%, and the proportion grew a little in 2019. This is largely the consequence of government

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incentives encouraging the purchase of electric and hybrid cars combined with incentives to encourage manufacturers to produce electric and hybrid cars and legislation to deter them from making cars powered by fossil fuels (Holland, 2020; McDonald, 2019; Lindeman, 2018). Nevertheless, in 2015 the Chinese government provided far larger subsidies for fossil fuel than any other country in the world (Coady *et al.*, 2019, p.5).

Regulations controlling emissions have been introduced in many areas of Europe resulting in increased demand for electric cars. For example, in London, electrically powered and hybrid cars are exempt from the congestion charge levied on fossil-fuel powered cars. Norway still offers extremely generous incentives to buyers of electric cars and penalizes people who continue to use gas or diesel cars. The capital, Oslo, offers toll-free roads, free parking and free charging for electric cars. At present, half of all new cars sold to Norwegians are either fully electric or hybrid. But it seems that Norwegians are beginning to realize that the principal problem is to reduce the total number of cars circulating in cities, not to switch cars from fossil fuel to being powered by electric-ity. Oslo is now planning to make its whole downtown area car free, and is reducing the benefits offered to electric car drivers (Lindeman, 2018; Wu *et al.*, 2019).

Most of the batteries being used to power electric cars are now lithium-ion. Production of lithium-ion batteries is very energy intensive. Lithium is a scarce mineral. Production of one ton of lithium requires either the mining of 250 tons of the mineral ore spodumene, or the pumping out of 750 tons of mineral-rich brine. However, should electric cars become widespread, recycling the lithium from old batteries would reduce the need for mining or pumping out minerals from brine (McManus, 2012; Harper *et al.*, 2019). Extensive research and development is under way to develop more efficient batteries (such as sodium-ion) to replace lithium-ion batteries.

For this and many other reasons, it is extremely difficult to forecast the proportion of the world car fleet that will be electrically driven. Recent forecasts vary widely, the highest being about 500 million, or roughly one-third of the total world fleet forecast by 2035 (Coren, 2019). The net contribution cars make to global warming could then increase significantly even if a substantial proportion was electrically powered. Nevertheless, given that most public transport and goods vehicles are much larger and more intensively used than private cars, the reduction in global warming resulting from changing these vehicles from fossil fuel to battery propulsion might be significant. Accordingly, from an environmental point of view, government encouragement of production and use of electric vehicles may well be justifiable. Systems for de-privatizing cars such as car-sharing, co-operative car clubs and smart car-hire schemes are being developed and are growing fast in some rich societies. Some cities in Europe and North America have been experimenting with bicycle sharing (Dennis and Urry, 2009, pp.94–6).

Reduction in the contribution of land transport to environmental damage requires complex combinations of measures worldwide. These could include reducing people's needs and desires to travel by transforming land use, together with measures to increase other means of personal mobility, at the same time as measures to increase substantially public transport's share of those journeys still needing to be undertaken. In the 1890s, few realized that automobiles – of which only a few primitive models had been produced – might solve the pollution problems caused by horse traffic in the world's largest cities within a few decades. Similarly, the research now being carried out could conceivably change road transport in ways impossible to anticipate. But despite the numerous uncertainties, a wise course would include planning for substantial reductions in the number of cars in the most prosperous regions of the world.

#### Sector study 2: sustainability of agricultural and food industries

Changes in dominant patterns of agricultural production and consumption during the last five hundred years have involved massive transfers of land away from peasants and small farmers. But they have also involved substantial agricultural innovations which have made possible enormous increases in agricultural productivity. During the last century, the world's agricultural and food

system, dominated by capitalism, increased food production immensely to cope with rapid growth in world population. Substantial changes have often been caused by changes in land ownership.

But food has not been distributed in accordance with people's need for healthy nutrition. Less than 60% of the world's population consumes an adequate amount and quality of food to maintain health. About 28% of consumers eat too little food and 15% consume too much, which can result in obesity and such chronic conditions as type 2 diabetes and cardiovascular disease. These effects are also partly the result of fast-food consumption, which has been increasing in many countries (Schlosser, 2002, pp.241–2; Foresight, 2011, pp.9–10). Production of food which, instead of meeting people's food needs, makes them obese and unhealthy is a waste of resources: inevitably it creates unnecessary global warming, pollution and other environmental damage.

After the first world war, some Americans, enthused by the Soviet Union's centralized industrial farming on a massive scale, were convinced of the obsolescence of the small farmer (Scott, 1998, pp.197–9). The rationale was the belief that small farmers' food production methods were inefficient and obsolete, and that their land could be better worked by large organizations. Mechanization has replaced many jobs which involved hard manual work, workers preferring more attractive non-farming jobs elsewhere. In many places, expansion of corporate capitalism is

transforming the very way in which countries farm. Many national systems have been converted to export-oriented agriculture, at the same time as the countries have been forced to open their own markets to food imports, including imports dumped on them by US and EU companies at less than the cost of production. As a result, millions of small farmers have seen their livelihoods destroyed. (Branford, 2011, p.4)

Moreover, about one third of global greenhouse emissions are now created by the industrial food system in agricultural production, land use change and deforestation, and processing, transport, packing and retail (Crippa et al, 2021).

Despite widespread declining trends, the number of small farmers and peasants living and working in developing countries is still enormous – more than two billion people out of a world population of over seven billion (Mashishi, 2016). Indeed, there are, and have always been, huge numbers of small local markets in which buyers can buy and eat sustainable, yield-rich food grown locally in relatively small ecological farms according to the natural cycle of the seasons (Patel, 2007, p.246).

The history of post-WWII food governance is essentially one of selling out public responsibility to markets and corporations. It is one of progressive disempowerment of the primary food security actors: the small-scale producers and the family units . . . Unprotected by state and intergovernmental directives, small scale producers are being driven off their land and out of their markets with the allegation that they are inefficient and archaic, ignoring the fact that they are responsible for producing some 70 per cent of the food consumed in the world. Increasingly, not only individual families but even nations have lost control over the aggregate body of factors that determine the food security of their populations . . . The food crisis is global, but it is rooted in local and national struggles against dispossession. (McKeon, 2015, p.3)

However, especially in less industrialized countries, small farmers and peasants have combined to form organizations to promote their interests. For example, the international peasants' movement claims that, with more than 200 million members of 182 organizations in 81 countries, it is the largest movement of peasant farmers and artisanal food producers in the world (Gomez, 2011; International Peasants' Movement, 2020). In summary, here are its principles of food sovereignty:

- 1. Everyone must have access to safe, nutritious and culturally appropriate food in sufficient quantity and quality to sustain a healthy life with full dignity.
- 2. Agrarian reform to give landless and farming people ownership and control of the land they work and returning territories to indigenous people.

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- 3. The sustainable care and use of natural resources, especially land, water, seeds and lifestock breeds.
- 4. National agricultural policies must prioritize production for domestic consumption and food self-sufficiency.
- 5. The control by multinational corporations is harmful to food sovereignty and should be curtailed.
- 6. Food must not be used as a weapon.
- 7. Smallholder farmers must have a direct input into formulating agricultural policies at all levels. (Branford, 2011, p.29)

On this basis McKeon (2015, p.198) has developed a hypothesis

that the food sovereignty movement constitutes a counter-force that has the potential of substantially altering the basis of food regime organisation by helping to fragment global hegemony and reconstitute a territorially rooted and governed approach to food provision. . . . [Food sovereignty] is attentive to ecology, the environment and biodiversity. It fights climate change and builds resilience. It is territorially rooted, bridges the distance between producer and consumer and furnishes healthy food for all. It binds agro-ecological modes of small-scale production with modes of processing and distribution that are appropriate to them and that create employment and stimulate local economies. It operates against inequalities.

Nevertheless, the barriers to the achievement of food sovereignty are considerable. For example, the International Peasants' Movement proposes – not unreasonably – that, to achieve food sovereignty, 'genuine agrarian reform is necessary which gives landless and farming people ownership and control of the land they work and returns territories to indigenous people' (Branford, 2011, p.29). But displacement of populations of small farmers and peasants to make room for the expansion of corporate agriculture is a world trend. Companies expel peasants and pastoralists from their land to secure large areas to produce food for export to rich countries or crops to be converted into fuels. Many farms – especially large ones – use intensive production methods, often focusing on monoculture. These farms require large inputs, such as water, fertilizers and pesticides (McKeon, 2015, p.4). The food they produce is generally not particularly conducive to human health, especially when it is subjected to intensive manufacturing processes before it reaches consumers (Blythman, 2015). Rationalization and intensification of farming and food production have occurred on a massive scale in relation to animal food as well as arable agriculture. They have resulted in extensive air, water and land pollution and environmental degradation, food poverty (especially in poorer countries) and poor conditions and low pay for workers in slaughterhouses and factory farms (Cudworth, 2013, pp.47–60).

Farms which use intensive production methods create huge quantities of noxious outputs, such as manure, and air and water pollution, which are seriously damaging to the environment. An increasingly intensive agricultural system is dominant throughout the world. This is mainly because its operators and proponents, including large farmers and suppliers of inputs (such as fertilizers herbicides and pesticides) in cooperation with state governments and international agencies such as the WTO, world bank and the international monetary fund, control the levers of economic power (McKeon, 2015, p.18). In summary:

The challenges remain daunting: corporate influence in politics at all levels and control of global food chains (and those for non-food agricultural products), as well as markets for inputs, especially seeds; the industrial 'cheap food' model on which too many consumers still rely out of necessity, preference or habit; the tenacious defence of globalized agricultural trade by influential states and powerful multilateral agencies, with their robust judicial apparatuses and dispute resolution and enforcement mechanisms; and the fact that biophysical threats to production from climate change are intensifying and beginning to wreak havoc on production in many of the world's poorest regions. (Edelman *et al.*, 2014, p.927)

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Modern farming uses monoculture and intensive methods of farming and mechanized tillage. Such methods also tend to make heavy use of chemical inputs, such as fertilizers and pesticides, and to cause soil erosion and depletion of nutrients in the soil. Biodiversity is diminished by concentration on a very restricted range of crops, produced using capital-intensive and input-intensive, large-scale methods. In contrast, traditional farming systems used by peasants and smallholders typically involve greater diversity of crops, year-round vegetation cover, lower levels of inputs, including energy, and less unused waste. For such reasons, they tend to be far less damaging to the environment.

The global food system is manipulated by corporations, together with other financial and powerful political actors serving their own interests. Despite overwhelming evidence to the contrary, it is still widely assumed that markets provide neutral and efficient arbitration. The present global food system is unsustainable environmentally and thoroughly inequitable. There is urgent need for reform. Food sovereignty offers the possibility of drawing on agro-ecological approaches to production, concentrating on local, national and regional markets, and emphasizing access to and control of natural resources by local populations (McKeon, 2015, pp.3–8).

#### Discussion

Economic organization changed radically throughout the world with the industrial revolution. In order to make, promote and supply large quantities and varieties of new products, companies needed to pay the people to manufacture them, to finance the factories and the machinery to make them, together with the transport to carry products to customers and the publicity to inform people that the products were available. Considerable skill and ingenuity were required in choosing and developing the products to make.

To have ensured, in addition, that the population of first England and then the rest of the world benefited more from the enormous increases in productivity which resulted from the industrial revolution would have required substantial capital expenditure. It would have required the construction of comfortable houses near factories; the prevention of environmental destruction and pollution caused by the construction of factories and other worksites and by their production processes; and regulations, together with encouragement for the growth of trade union power, to make sure that the conditions and pay of workers were fair. What actually happened was just about the opposite of this.

By the late twentieth century, after many political and economic twists and turns, laissezfaire followed by various neoliberal creeds had been adopted by many governments, including in Russia and the former satellite states of the Soviet Union following the end of the communist 'experiment'. Locations of production change as capitalists in search of profits close down production facilities in some countries and establish new ones in other countries; for example, because labour costs may be lower in new countries. Both gaining and losing major employment opportunities causes huge disruption in people's lives and the environment. It is probable that the worldwide application of food sovereignty principles would result in a far more effective system of agricultural and food production involving substantially less damage to the environment than the present system. This is thoroughly dysfunctional from every point of view except that of large corporations.

Neo-classical economists continue to assume (at least implicitly) that there is always an invisible hand which assures that consumer demand is the main driver of production in capitalist economies. Such an assumption may have had some validity in the late eighteenth century, being based on contemporary economies in which traditional products were often made locally in small quantities by traditional methods out of traditional materials. But well before the end of the twentieth century, mass factory production of new products manufactured by new methods, using new materials and components, together with enormous expansion of transportation of materials, components marketing and advertising, had rendered the assumption invalid. Strategic developments had come to be implemented by companies, often in consultation with governments and with substantial financial support from them, but with little input from consumers. And monumental expenditure on

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advertising and other forms of promotion surely had substantial influence on consumers' decisions. Few decisions made by companies and governments take environmental considerations into sufficient account. Parts of the same government's policies may have contradictory environmental effects. For example, China's government is the most prominent in the world in promoting production and sales of electric cars, ostensibly to reduce cars' impact on the environment. At the same time, the Chinese government also provides the world's largest fossil fuel subsidies.

This paper – in particular the sector studies – demonstrates that restricting the damage to the environment resulting from human economic activity is a complex problem. The principal solutions offered by economists have involved the creation of carbon markets. Such measures are both ineffective now and unlikely to be effective in the future because of complications involved in implementation and serious inaccuracies in assumptions on which they are based. Current policies to restrain environmental damage focus very strongly on attempting to contain global warming; but there are other policy issues, in particular related to the damage caused by mineral extraction and by reduction in biodiversity. Solutions to the world's environmental problems must be holistic. It will not, for example, be enough to develop policies to restrict the damage caused by climate change if such policies do little to contain the problems caused by mineral extraction.

Some governments are anxious to restrain global warming and environmental pollution. But governments efforts to move in such directions have been severely restricted by the ability of major corporations to offer the incentive of economic growth in return for not interfering with their operations. Foley *et al.* (2016) argue that the focus of companies must be less on increasing shareholder value and more on the benefits for all stakeholders, but it is difficult to see what stimuli might drive such radical change.

Following Polanyi's line of reasoning, we are led, I believe, to conclude that the nature of the capitalist system drives far too many enterprises toward environmentally destructive practices, drives far too few enterprises toward stewardship practices, and ensures that governments will fail to meet the resulting sustainability challenge. My reading of Polanyi suggests that enterprises in a capitalist economy cannot change their environmental practices far or fast enough to avert environmental crisis - neither spontaneously under the influence of wiser corporate leaders, nor pushed by greener consumers, and not even forced by more active government regulation. (Adler, 2015, p.4)

Adler also identifies the need for global integration over many years to allow 'the massive R&D effort needed to develop new energy and  $CO_2$  absorption technologies to be funded', and 'to drive a rapid transformation of our power, water, industrial, housing, agricultural and transportation systems' (Adler, 2019, p.137).

Many economists believe that market and price changes could make very substantial contributions to the solution of environmental problems and such views are highly influential in the formation of policies. This paper casts doubt on their efficacy. It concludes that international multidisciplinary teams of scientists, technologists, engineers, historians and social scientists should be established. They should be asked to assess the damage to the environment caused by human economic activities, and to advise on the best approaches to reduce the damage. Their research and analysis need to be holistic and broad-ranging, concentrating on empirical and historical analysis rather than theory – and on presenting results clearly to wide audiences, including policymakers, as soon as possible.

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# **RESEARCH PAPER**

# The impact of persistent innovation on Australian firm growth

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# ABSTRACT

This paper assesses the contribution of innovation persistence to surviving Australian firm growth performance over the period 2007–08 to 2013–14 with the added advantages that new firms, micro-sized firms and all industry sectors are included in our analysis. Over this period, firms with high sales and/or employment growth accounted for the majority of aggregate economic and employment growth in Australia, which is consistent with similar studies in other countries. Using a randomized, stratified sample from a firm population-level database that links administrative, tax and survey data, we created a matched, balanced sample of surviving firms to show that short-term persistent innovators (particularly young SMEs) significantly outgrow their less persistent and non-innovator counterparts in terms of sales, value added, employment and profit growth. Persistent innovators are more likely to be high-growth firms and more likely to introduce multiple types of innovation that are more novel. Our findings suggest that broad-based innovation policies may support successive waves of high-growth firms that help to sustain economic and employment growth in Australia.

# Introduction

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The literature on the persistence of innovation and its positive association with firm growth has itself experienced high growth. Understanding what drives high-growth episodes in firms is fundamental for designing industry policies to drive employment and/or economic growth. High-growth firms, not surprisingly, contribute disproportionately to aggregate economic and employment growth in most countries, but high-growth firms themselves tend not to maintain their high growth in the medium to long term (Coad, 2018).

Research to date shows that Australian economic and employment growth dynamics are consistent with the stylized facts for high-growth firms identified in Moreno and Coad (2015) and Coad *et al.* (2018). High employment growth and/or high sales growth (high-growth) firms generated the majority of Australia's net aggregate growth, accounting for 92% of net positive employment growth, 86% of net positive sales growth, 92% of net export sales growth, and 89% of net positive economic growth over the period 2007–14 (Hendrickson *et al.*, 2018; Table A1). While the definition of a high-growth firm used was broad, the findings had the added advantages that they included all economically active firms in Australia, including new firms and micro-sized firms from all sectors of the Australian economy. These results were consistent with other research using a narrower definition of high growth (Hendrickson *et al.*, 2015; Moreno and Coad, 2015). More than half of Australian firms end their high sales growth episode within four years. This tends to occur when the firm is new, more innovative and more strategic (Hendrickson *et al.*, 2015; Australian Government,

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2016; Hendrickson *et al.*, 2016; Majeed *et al.*, 2021). Collective evidence points to innovative firms growing more on average than their non-innovator counterparts and also being more likely to be high-growth firms, all else being equal (Cefis and Ciccarelli, 2005; Hasan and Tucci, 2010; Czarnitzki and Delanote, 2013; Audretsch *et al.*, 2014; Ciriaci *et al.*, 2016; Bianchini *et al.*, 2017; Calvino and Virgillito, 2018). These results, while significant, are often small or inconsistent and vary by country, firm size, age and sector, especially when using dummy variables based on community innovation survey-style data (Mohnen and Hall, 2013). The persistence with which firms innovate appears to be one mechanism mediating the strength of this relationship, at least in the short term (Segarra and Teruel, 2014; Bianchini and Pellegrino, 2019).

There is no commonly accepted definition of firm innovation persistence. The basic concept is that a firm must introduce one or more innovations in any given year in consecutive years. The theoretical arguments exploring why a firm should persistently innovate and why its many associations with different forms of growth have been shown to overlap, be complementary and be self-reinforcing have been exhaustively reviewed elsewhere. Most researchers invoke the Schumpeterian argument of creative-destruction, whereby innovation promotes competitive reallocation of market shares to the innovators that enjoy higher growth and/or profitability. Persistence in innovation, or where innovation success generates profits that can be reinvested in more innovation (Duguet and Monjon, 2004; Ganter and Hecker, 2013; Haned *et al.*, 2014; Hecker and Ganter, 2014; Le Bas and Scellato, 2014; Máñez *et al.*, 2015; Moreno and Coad, 2015; Calvino and Virgillito, 2018).

Research on British, Swedish, Italian, Spanish, Flemish, Finnish and French firms shows strong correlations between innovation persistence and growth in profitability, sales, employment and/or productivity growth (Cefis and Cicarelli, 2005; Czarnitzki and Delanote, 2013; Deschryvere, 2014; Triguero *et al.*, 2014; Lhuillery, 2014; Baum *et al.*, 2015; Bartoloni and Baussola, 2015, 2016). It is rare, however, that more than one growth indicator is measured. A study of young, small, innovative Flemish companies that had 11% and 5% higher sales and employment growth, respectively, compared firms with some of these characteristics but not all three (Czarnitzki and Delanote, 2013).

Predicting the success of innovation investment is more often a random exercise at the firm level because it is an inherently uncertain 'double-edged sword' (Moreno and Coad, 2015). The returns to innovation are highly skewed in a population of firms, with the most extreme impacts of R&D expenditure on firm growth found at the tails of a growth distribution (Coad and Rao, 2008; Majeed *et al.*, 2021). Given the similarities, the unpredictable and stochastic nature of firm growth may reflect, in part, the unpredictable and stochastic outcomes of innovation (Geroski, 1999). Evidence from Spanish manufacturers and Finnish firms suggests that there is no point targeting specific firms to generate long-term employment growth for society as the benefits of innovation are highly uncertain; competitive advantages seem to erode over time and quite quickly (Deschryvere, 2014; Coad *et al.*, 2018; Bianchini and Pellegrino, 2019).

In this context, many prior research efforts tend to isolate our understanding to the role of a specific type or types of innovation<sup>1</sup> and its persistence in driving a particular type of growth (typically employment growth). Few studies tend to embrace all types of innovation and fewer still focus on sales or industry value-added growth. Panel studies of French and Luxembourg firms show that those introducing more than one type of innovation are more persistent innovators than those introducing only one type in any given year, with the authors arguing that there are synergistic relationships between new products and the new processes and the organizational changes required to support them (Mohnen and Hall, 2013; Haned *et al.*, 2014; Le Bas and

<sup>&</sup>lt;sup>1</sup>Here we refer to the separation by the Working Party of the National Experts on Scientific and Technology Indicators (2005) of innovation into four interrelated types: product, process, organizational/managerial and marketing innovation.

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Poussing, 2014; Hecker and Ganter, 2014). Recent research shows that firms introducing more than one type of innovation were found to have superior growth and market share performance, as the development of complementary innovations encourages more repeated, systematic innovation capability in firms (Bartoloni and Baussola, 2016; Bianchini *et al.*, 2018; Arranz *et al.*, 2019). This was shown to have overall positive effects on economic growth (Evangelista and Vezzani, 2012).

This paper responds to calls for a multi-dimensional approach to examining the contribution of innovation to firm growth (Audretsch et al., 2014) with a more systematic effort to link firm-level and country-level dynamics (Calvino and Virgillito, 2018). Our study sought to validate earlier economic and employment growth research on predominantly European firms. Australia arguably has a strong national innovation system compared with many other countries so we would expect to see a stronger relationship between innovation output and firm growth (Segarra-Blasco et al., 2018). Our research questions are: What is the contribution of persistent innovation to high growth compared with that of firms that do not innovate or innovate less frequently? Are persistent innovators more likely to be high-growth firms? We used a longitudinal dataset of all economically active Australian firms where the contribution of high sales and/or employment growth to a range of aggregate growth indicators has been established (see Hendrickson et al., 2018). We used a randomized, stratified sample of firms from this same population where innovation activity is more extensively measured to confirm the firm-level relationship between short-run innovation persistence and growth across a range of growth indicators at the firm level. Our paper measures different degrees of persistence in innovation to help quantify the magnitude of the effect of innovation on different types of firm-level growth, and the relationship of innovation persistence to high-growth spells. In our study, we include all types of innovation (product, process, organizational/managerial and marketing) in our measure of persistence and we measure their combined effects on several types of growth (turnover, gross output, value-added output, and/or employment).

#### Method

A complete description of the data and methods employed is available at http://www.prometheusjournal.co.uk/ *Supplementary Data*. Figures A1 and A2, and Tables A1–A11 are all to be found among the supplementary data.

#### Data

We used 2007–08 to 2013–14 firm-level data extracted from the Australian Bureau of Statistics, *Business Longitudinal Analytical Data Environment* (Australian Bureau of Statistics, 2015). Our study overcomes the disadvantage of many studies of innovation persistence and growth in that both new and micro firms are included in our dataset (see Coad *et al.*, 2018). Unlike many persistence studies that work with manufacturing firm datasets (e.g., Guarascio and Tamagni, 2019) our dataset includes firms from all sectors of the economy. No market information, such as stocks, prices or volumes of sale, was available in this dataset.

To validate the presence of cumulative effects from innovation persistence, we used a balanced panel sample derived from the business characteristics survey and additional units selected from the business longitudinal database SME panels that exist in all financial years from 2010–11 to 2012–13. In total, there were 6,142 firms; among these, 74% were simple-structured firms<sup>2</sup> and 26%

<sup>&</sup>lt;sup>2</sup>These firms operate in one industry, have a single Australian business number and are concentrated in the small to medium business size group (i.e., employing fewer than 200 employees). Only 4% of this sample were businesses with 200 or more employees.

were large, complex-structured firms<sup>3</sup> (see Table A2). Firms that had abandoned innovation projects or had innovation projects still in development were excluded from the sample. Innovation activity was measured on a winsorized, randomized, stratified and representative sub-sample (approximately 14,000 to 17,000 firms per annum) of the full Australian firm population using the business characteristics survey conducted by the Australian bureau of statistics. This survey is collected following the guidelines of the Oslo Manual (National Experts on Scientific and Technology Indicators, 2005) and generally shares the innovation definitions and collection practices of community innovation survey datasets. However, the response rates are higher at ~95% and firm size and industry classifications. Persistent innovators comprised 13,107 individual observations or 37% of the sample.

#### Definitions

For growth analysis at the national level, we define a high-growth firm as having annual growth in total sales and/or employment of greater than 20% over the previous year. This definition is based on organization for economic cooperation and development (OECD) relative definitions of high growth. For modelling, we sub-classified firms by age and size. SME firms are generally defined as 0–199 employees and large firms with 200+ employees.

There is no commonly accepted definition of firm innovation persistence. Our concept of innovation persistence is that a firm must introduce one or more innovations in any given year in consecutive years. In this study, we examined the performance of Australian firms that reported innovation persistence over a three-year period similar to the method used by Lhuillery (2014) and Bartoloni and Baussola (2016). In our study, the most persistently innovating firm would be one that introduced at least one innovation in three out of the three years examined. A non-innovating firm would have introduced no innovations over the same three-year period.

Given the balanced nature of our panel data, we were able simply to look at the frequency with which a firm reported introducing one or more innovations within a three-year window. We note that this is not a true measure of innovation frequency. A recently introduced innovation survey question shows that most Australian firms introduce only one or two innovations of each type every year; however, at least 20% of innovation-active firms introduced three or more of each type of innovation in 2014–15. This appears to be size- or age-dependent (Australian Bureau of Statistics, 2016). We also chose to consider all types of innovation in our definition of persistence as recent evidence suggests that the interaction between the types of innovation can be both synergistic and simultaneous (Arranz *et al.*, 2019), with these complex innovators being more persistent than single innovators (Le Bas and Scellato, 2014). Isolating each type of innovation may therefore create significant omitted-variable bias.

Longer panels were not possible because of the way the Australian Bureau of Statistics rotates SMEs out of the survey sample frame every three to five years. Censoring of the innovation window was not employed in this paper as we were more interested in an intensity measure than specific timing or lag effect. Given that more than 90% of innovating Australian firms in our dataset reported some benefit of their innovation(s) in the same year as introducing it (Australian Bureau of Statistics, 2014),<sup>4</sup> we allowed for analysis of growth patterns in the same year as an innovation(s) was introduced. This approach is consistent with the findings from Spanish firms

<sup>&</sup>lt;sup>3</sup>Large, complex-structured firms operate in more than one industry, and have more than one Australian business number. All complex-structured firms in the sample had 200 or more employees, with the majority (96%) having 300 or more employees.

<sup>&</sup>lt;sup>4</sup>The reference year for this survey question was 2012–13.

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(Triguero *et al.*, 2014; Arranz *et al.*, 2019). Benefits reported by Australian firms in the same year included improved customer service, increased revenue, competitive advantage and reduction in costs (Australian Bureau of Statistics, 2014). Time lags were therefore considered less relevant for these short-term benefits and therefore not included in our models at the risk of reverse causality constraints.

We used new to market innovation as our measure of novelty. New to market innovations are innovations of any type that are reported either as new to the world, new to Australia or new to the industry. As the new to market innovation (novelty) question is asked only every second year, values were imputed based on highest response from the years the questions were asked. Novelty was not included in our matching study because of the imputation.

#### Outcome and performance measures

For firm-level analyses, we measured growth in turnover or total sales, employment and value-added output, but we also report gross operating profit (sales of goods and services minus cost of goods sold) and gross output (total firm income plus the value of changes in inventories of goods produced as outputs). Table A3 provides variable definitions and derivations from the dataset.

#### Descriptive analysis and Analysis of Variance (ANOVA)

We undertook a cross-sectional ANOVA and measured interaction effects for innovation novelty and average turnover or total sales, value-added, gross operating profit and employment growth outcomes against innovation persistence. We used percentile distribution analysis to describe variation in firm growth variables by innovation persistence and firm size-age classes. We compared the 10th, 25th, 50th, 75th and 90th percentiles of the growth distribution of each level of innovation persistence (see Ciriaci *et al.*, 2016). Quantile regression was used to validate statistical significance of each innovation treatment at each of the above quantiles.

# Regression modelling

Propensity score matching is a statistical technique that improves the estimate of a treatment effect by accounting for the covariates that predict receiving the treatment (see Rosenbaum and Rubin, 1983, 1985). We used a doubly robust method of outcome regression and propensity score matching to limit selection bias by matching each innovating firm with one or more non-innovating firms that otherwise have the same or similar observed characteristics (Funk *et al.*, 2011; Tavassoli and Karlsson, 2017). The variables used to construct a propensity score are listed at Table A4.

In the current study, the inclusion and creation of the key firm characteristics for the propensity modelling are based on previous innovation studies and analysis already conducted and/or published by the Australian Bureau of Statistics (Todhunter and Abello, 2011; Antonelli *et al.*, 2013; Rotaru *et al.*, 2013; Rotaru, 2013; Fagerberg and Mowery, 2015; Soriano and Abello, 2015). Sample bias reduction using these variables is shown in Figure A1. The positive association between firm growth and firm size has been found to be the result of firm ageing, a form of Simpson's paradox (Coad, 2018). While we recognize this risk, we control for both age and size. While age can influence the likelihood of firm senescence, size can lead to variable investment and economies of scale and scope. We controlled for age to correct partially for high-growth bias from small, new firms in our dataset, following Ciriaci *et al.* (2016).

After matching firms based on their propensity score, we assessed the magnitude of the cumulative effect of the persistence of innovation on selected firm growth outcomes. We ran ordinary least

square regressions on the matched sample, defined as the observations in the treatment group plus the matched observations in the control group. The model in this case can be written as:

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Log (Ratio of two outcomes) = F (Innovation persistence,  $X_1$ )

where:

 $X_1$  = a vector of covariates defined as in the propensity model.

Innovation persistence was an ordinal innovation variable with an increasing number of years in which a firm introduced at least one innovation. Two different model specifications were used. The first model used a dummy variable for each of the innovation persistence variables, while the second model used the years of persistence as a variable in the model. An example for log of value-added ratio between 2013 and 2011 is provided below using definitions from Table A3:

$$Log(VA Ratio_{i}) = \beta_{0} + \sum \beta_{Pi}P_{i} + \beta_{A}Age_{i} + \sum \beta_{Ei}Emp_{i} + \sum \beta_{Ci}Comp_{i} + \sum \beta_{Ii}ICT_{i} + \sum \beta_{Fi}Foreign_{i} + \beta_{G}Gov_{i} + \beta_{O}Coop_{i} + \beta_{W}FWA_{i} + \beta_{X}Export_{i} + \beta_{S}Skills_{i} + \beta_{K}Skills_{i} + \beta_{K}Skills_{i} + \beta_{F}Other \quad finance_{i} + \sum \beta_{Fi}Ind_{i} + \varepsilon_{i}$$

where:

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VA Ratio, is the ratio of 2013 Value Added and 2011 Value Added of firm I;

 $P_i$  is a binary variable for each of the innovation persistence categories – including being innovators for three, two and one year in the study period – three variables, reference case is not innovation active;

Age<sub>i</sub> is a binary variable, taking value 1 if the firm's age is more than five years, zero otherwise;

 $\text{Emp}_{i}$  is a binary variable, taking value 1 for each of the firm's number of employees categories – 1–4, 5–19, 20–199, 200–99 and 300+ employees – five variables, reference case is non-employing firms;

 $Comp_i$  is a binary variable, taking value 1 for each of the degree of competition categories – Minimal and Moderate to Strong competition – two variables, reference case is no effective competition;

ICT<sub>i</sub> is a binary variable, taking value 1 for each of the ICT intensity categories – Moderate, High and Most Intense – three variables, reference case is Low intensity;

Foreign<sub>i</sub> is a binary variable, taking value 1 for each of the foreign ownership categories -0-50% and >50% ownership, reference case is 100% Australian owned;

Gov<sub>i</sub> is a binary variable, taking value 1 if the firm receives government assistance, zero otherwise;

Coop<sub>i</sub> is a binary variable, taking value 1 if the firm is involved in any cooperative arrangement, zero otherwise;

FWA<sub>i</sub> is a binary variable, taking value 1 if the firm has flexible working arrangements, zero otherwise;

Export, is a binary variable, taking value 1 if the firm engages in exporting activity, zero otherwise;

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Skills, is a binary variable, taking value 1 if the firm reported that its employees use some specific skills, zero otherwise;

Skills\_Def<sub>i</sub> is a binary variable, taking value 1 if the firm reported having skills deficiency or shortage, zero otherwise;

Other\_finance<sub>i</sub> is a binary variable, taking value 1 if the firm sought debt and equity, zero otherwise;

 $Ind_i$  is a binary variable, taking value 1 for each industry division – 16 variables for the market sector industries excluding public sectors, reference case is agriculture, forestry and fishing; and

 $\varepsilon_i$  is the error term,  $\varepsilon_i \sim N(0, \sigma^2)$ ,  $Cov(\varepsilon_i, \varepsilon_j) = 0$  for  $i \neq j$ .

We ran ordinary least squares (OLS) regression on all growth variables. We ran OLS regression with and without controlling for capital expenditure and found no major difference in the results. The results presented in this paper are those without controlling for capital expenditure. In this study, we measured growth as the difference between time t and time  $t_{-3}$  for simple- and complex-structured firms for each growth variable. An additional sample (called total sample) was used where we added a simple/complex dummy variable in the covariates for the propensity score modelling. This addressed the issue of a simple-structured firm being matched to a large, complex firm, and vice versa.

#### Results

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#### The contribution of innovation persistence to growth

Figure 1 shows the median growth rates for SMEs (0–199 employees) and large firms (200+ employees) for two three-year panels between 2008 and 2014. The data suggest that innovation has a positive correlation with sales, value-added, profit and employment growth outcomes in Australian firms. The positive effect of innovation was greatest for persistently innovating firms. For example, median annual sales growth for SME non-innovators was -\$1,890 over this period. In contrast, median annual sales growth for persistent SME innovators was +\$12,763 over the same period (Figure 1). The less regularly that firms reported innovating over a three-year period, the weaker the differences between innovator and non-innovator growth rates became, suggesting an innovation dose effect.  $( \mathbf{\Phi} )$ 

It is interesting to note that the relationship between innovation persistence and median profit and employment growth is positive, but has quite different scales depending on the phase of the business cycle (data not shown). Analysis of variance on these two three-year panels confirmed that the mean differences in growth performance were significantly different between firms of varying innovation persistence. ANOVA and interaction effects tests on both three-year panels showed significant positive differences between innovation persistence least squares means for sales growth (F=42, p<0.0001), value added growth (F=537, p<0.001), gross operating profit growth (F=17, p<0.0001) and employment growth (F=12, p<0.05). Note that the panel data were pooled and are unlikely to satisfy the independence test.

Differences in growth rates between firms that innovated once in three years and noninnovators (zero out of three years) were often insignificant, particularly large firms, except at higher/lower percentiles in the growth distribution where the growth differences between levels of innovation persistence became distinct (Figure A2; Tables A5 and A6). Consistent with sales data from Coad and Rao (2008), quantile regression showed a significant difference in growth coefficients between innovation persistence categories for all growth measures ( $\chi^2$ >1,900; DF=16, Pr> $\chi^2$ <0.0001 in all cases). Errors are 95% confidence intervals using bootstrap resampling.

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*Note:* Innovation persistence, number of years (out of three) in which a firm introduced an innovation. Employment growth is measured in full time equivalents. Sales, value-added and gross operating profit dollar values are not deflated. Errors are 95% confidence intervals using bootstrap resampling.

Source: Australian Bureau of Statistics (2017) Business Longitudinal Analysis Data Environment, 2001-2 to 2013-14.

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As with the results of Czarnitzki and Delanote (2013) and Ciriaci *et al.* (2016), a stronger effect of innovation and innovation persistence on growth performance was found at the higher percentiles of the growth distributions for all four growth indicators examined (total sales, employment, value added and gross operating profit; Tables A5 and A6). Among the growing SMEs, persistently innovating SMEs grew more in absolute terms than non-innovators and less frequent innovators. Among the growing large firms, persistently innovating firms grew more in absolute terms than non-innovators and less frequent innovators. The results for large firm growth quantiles were consistent with the employment growth results from Spanish firms reported by Ciriaci *et al.* (2015). At the lower growth quantiles, persistent SME innovators had more extreme negative

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growth whereas there was either no difference or a protective effect at lower quantiles for large persistent innovators compared with non-innovators (Figure A2; Tables A5 and A6).

We compared the firms in this randomized and stratified sample with the full population of all economically active firms over that same period. Hendrickson *et al.* (2018) showed that high-growth firms (HGFs)<sup>5</sup> in the full population generated the majority of growth in all four growth measures over this period. As expected from the above results, Table 1 shows that the overall likelihood of satisfying the definition of a high growth firm increased with the level of innovation persistence across all growth indicators measured. By simulating a randomized control trial with the broadest range of firm characteristics available at the time, we were able to confirm the influence of innovation persistence on a range of three-year turnover, value-added output, gross output, gross operating profit and employment growth outcomes using firm characteristics from 2011 as covariates and non-innovators as the control group. Our definition of growth was the difference between the first- and third-year values of each performance variable.

Percentage likelihood of high-growth-firm s	tatus					
Innovation persistence		SMEs	Large firms			
Innovation persistence, number	Annual net sales growth					
of years (out of three) introducing one or more innovations	0	14.6	9.1			
	1	15.9	12.1			
	2	17.2	12.4			
	3	19.7	12.3			
	Annual net gross operating profit growth					
	0	15.3	8.7			
	1	16.0	12.1			
	2	17.4	13.2			
	3	20.8	12.5			
	Annual net value-added output growth					
	0	15.0	9.2			
	1	16.1	11.9			
	2	17.6	12.3			
	3	19.7	12.3			
	Annual net employment growth					
	0	16.9	9.2			
	1	18.2	12.2			
	2	17.8	12.4			
	3	19.6	12.3			

**Table 1.** Percentage likelihood of being a high-growth firm by growth measure, innovation persistence and<br/>firm size, 2008–14

Note: A high-growth firm was defined as a firm achieving annual growth in sales and/or employment of more than 20% over the previous year.

Source: Australian Bureau of Statistics (2017) Business Longitudinal Analysis Data Environment, 2001–2 to 2013–14.

<sup>5</sup>HGFs defined as having annual growth in sales and/or employment of more than 20% over the previous year. <sup>6</sup>A new-to-market innovation is one that is new-to-world, new-to-Australia or new-to-industry.

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The regression results from the matched sample provide doubly robust evidence of the positive association between persistent innovation and a range of growth outcomes, particularly for SMEs and simple-structured large firms. Table 2 summarizes the results for two OLS regression models using persistence group dummy variables for a range of growth variables. Complete regression outputs are in *Supplementary Data* (Tables A7 to A11). Estimates are broken into their effect on simple-structured firms, complex-structured large firms and the total sample.

There were positive and significant coefficients for the persistence variables under both models, confirming the cumulative effects of innovation persistence measured by ANOVA and quantile regression. This effect was strongest in simple-structured firms, which were mostly SMEs. The effect of innovation on growth generally weakened the less persistently that simple-structured firms innovated over the three-year period. For example, persistent simple-structured innovators that innovated in all three years had 16% and 17% higher gross output and value-added output growth respectively compared with firms that did not innovate in any of those three years (Table 2). Although not presented here, we also tested the relationship with wage and salary growth and found this to have a significant, positive relationship with innovation persistence in simple-structured firms (see Hendrickson *et al.*, 2018). This is consistent with employment growth results.

The matching and regressions were less robust for large complex firms because the total firm counts were low and there were fewer controls to match. A consistent, significant effect was still found in large complex firms for turnover and profit. However, unlike the simple-structured firm cohort, large complex firms appeared to benefit from the presence of innovation rather than any innovation persistence *per se*.

Simple-structured firms that are new, have high ICT and skills intensity, have cooperative arrangements and demand for external finance are also more likely to grow after matching on other covariates (Tables A7–A11). Interestingly, once matched to similar firms, the results all agree that growth was less likely in simple-structured firms that have foreign ownership. There were some

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# Figure 2. Percentage likelihood of introducing a new-to-market innovation by innovation persistence, 2008–2014

*Note:* New-to-market innovation includes new-to-industry, new-to-Australia and new-to-world degrees of novelty. Error bars are 95% confidence intervals taken from bootstrap resampling. Data from both panels were pooled for this chart. *Source:* Australian Bureau of Statistics (2017) *Business Longitudinal Analysis Data Environment*, 2001–2 to 2013–14.

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effects from firm size, although only statistically significant in one size category (20–199 employees), which may reflect controlling for age. The presence of competitors had a positive effect on the growth of simple-structured firms, but had no influence on larger, complex-structured firms.

Innovation persistence and innovation novelty were also found to be correlated in both large and SME firms (Figure 2). The percentage likelihood of a persistent SME innovator introducing a new-to-market<sup>6</sup> innovation is two to six times higher than that in less frequent innovators, consistent with Calvino and Virgillito (2018). Innovation persistence and multiple types of innovation are likewise correlated. In the matched, balanced panel sample, the majority of firms innovating in all three years was introducing multiple innovations in a single year, typically of different innovation types and many introducing three or more types of innovation in any given year of the panel (Table A2).

		Р	Persistence - (model 2)		
Sample	Growth variable	Innovators for 3 years	Innovators for 2 years only	Innovators for 1 year only	Number of years of innovation
Simple- structured firms	Gross operating profit	0.111	0.007	0.053	0.029
	Employment (FTE)	0.173***	0.107***	0.006	0.057***
	Turnover	0.173***	0.115***	0.034	0.057***
	Gross output	0.163***	0.113***	0.008	0.055***
	Value added	0.174***	0.093***	-0.008	0.055***
Large, complex- structured firms	Gross operating profit	0.169**	-0.018	0.360***	0.044*
	Employment (FTE)	0.027	0.061**	0.090***	0.012*
	Turnover	0.070***	0.060**	0.096***	0.024***
	Gross output	0.025	0.014	-0.015	0.008
	Value added	-0.079	-0.021	-0.091	0.008
Total sample	Gross operating profit	0.174***	0.011	0.125***	0.047***
	Employment (FTE)	0.098***	0.087***	0.025	0.035***
	Turnover	0.159***	0.119***	0.073***	0.054***
	Gross output	0.114***	0.081***	0.011	0.039***
	Value added	0.091***	0.067***	-0.009	0.039***

Table 2.	Summary of the	impacts of	f innovation	persistence	on various	measures of firm	growth us	sing a
	derived balanced	l matched	panel and O	LS regressio	on, 2010–13	3		

*Note:* Model 1 treats persistence as a categorical/dummy variable while Model 2 uses one variable to capture the number of innovation years. Values are the percentage difference from the non-innovator control dummy. \* p<0.1; \*\* p<0.05; \*\*\* p<0.01; Definitions of each growth indicator are at Table A3. Detailed regression outputs, including covariates, are found in Tables A7 to A11. FTE = full time equivalent.

Source: Australian Bureau of Statistics (2017) Business Longitudinal Analysis Data Environment, 2001-2 to 2013-14.

#### Discussion

The results of this paper are consistent with the current literature on innovation persistence reporting significant individual effects on growth in innovating firms, especially persistent innovators (Cefis and Ciccarelli, 2005; Deschryvere, 2014; Triguero *et al.*, 2014; Lhuillery, 2014; Baum *et al.*, 2015; Ciriaci *et al.*, 2015; Bartoloni and Baussola, 2015, 2016; Calvino and Virgillito, 2018; Bianchini and Pellegrino, 2019). Our data show that Australia follows many of the stylized facts on aggregate growth dynamics common to other countries examined to date. Sales, value-added output

and employment growth in Australia are consistent with firm age and growth literature, with the added advantages that we included all economically active firms in our analysis including new and micro-sized firms from all sectors of the economy. High-growth firms in aggregate drive net positive economic and employment growth in the economy.

We used a randomized and stratified sub-sample of the Australian firm population to show that surviving, short-term persistent innovators had higher sales, value added, gross operating profit and employment growth than non-innovators and less frequent innovators. Persistent innovation also appears to affect positively net economic and employment growth dynamics as we found that annual growth is more likely to be net positive for persistent innovators than for non-innovators and less frequent innovators. Systematic innovation may therefore be one of the major mechanisms behind aggregate growth dynamics rates, particularly for the percentage contribution of SMEs and simple-structured large firms to aggregate economic and employment growth.

Our data also support the argument that persistent innovators are more likely to open new markets and increase demand for their products, reflecting the complementary or compounding benefits of several types of innovation being introduced together (Antonelli *et al.*, 2012; Goedhuys and Veugelers, 2012) and the importance of innovation novelty in capturing market share (Moreno and Coad, 2015; Coad, 2018). We argue that some of our results in different panels are consistent with Dachs *et al.* (2016) and Calvino and Virgillito (2018), who argue that the impact of innovation in all its forms can be both pro-cyclical during the growth phase of the business cycle and counter-cyclical during downturns.

Large mature high-growth firms made a significant per firm and aggregate contribution to net positive economic and employment growth in Australia over the period studied. Large firms have higher rates of innovation persistence than SMEs (Cefis and Orsenigo, 2001; Roper and Hewitt-Dundas, 2008; Máñez *et al.*, 2015). While the association between innovation and growth in these firms is apparent in turnover and profit, the positive association with innovation persistence is not as obvious in large complex-structured firms, except when viewed at the higher end of their growth distribution (Deschryvere, 2014). Other research suggests this phenomenon arises because large and/or mature firms are less agile and therefore able to leverage their innovations for competitive advantage (Coad *et al.*, 2018) or because the relationship between organizational/management control and firm performance can be more opaque in complex structured firms (Le Bas and Scellato, 2014).

The results support the argument that older firms find it harder to adapt and take advantage of changing market conditions, despite more frequent innovation events than younger, smaller firms (Coad *et al.*, 2018). Firm ageing was often a significant negative factor influencing growth (Coad, 2018), and was particularly stark for profit and employment growth for large complex-structured firms. More than 90% of Australian firms reported innovating for profit reasons in 2012–13 (Australian Bureau of Statistics, 2014). It should be noted, however, that large Australian firms were significantly more likely to undertake innovation to address issues that do not necessarily capture market share. In 2012–13, large firms were almost three times more likely than micro firms to innovate in response to government regulations or to improve safety or working condition, and twice as likely to innovate to reduce environmental impacts or adhere to industry standards. Another compelling explanation is that, overall, Australian SMEs are more dependent on innovation for sustaining growth at their maximum desired size. Australian firms with 200+ employees report that innovation from new goods and services generates only 3% of their income. This was closer to 11% for firms with 5–199 employees and 21% in firms with 0–4 employees (Australian Bureau of Statistics, 2016).

#### Policy implications

The results of this paper clearly illustrate the risky nature of public and private investment in innovation. Figure A2 clearly shows the double-edged sword described by Moreno and Coad (2015).
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The short-term growth percentile distributions in our study show that persistently innovating SMEs tend to be 'boom or bust' risk-takers: if they succeed, they grow faster, and if they fail, they fail harder than non-innovators. However, our results also show that innovation persistence helps create net-positive growth in sales, value-added, gross operating profit and employment. For large firms, persistent innovation has good betting odds. If they fail, they seem not to fail harder than non-innovators.

During the 2012–13 year, lack of access to additional funds was the most frequently identified barrier to innovative activity in Australian SMEs, at around 30% of firms reporting a barrier to innovation. Large firms were more likely to report cost of development or introduction/implementation over the same period (Australian Bureau of Statistics, 2014). Direct government financial support may therefore reduce the downside risk of innovation investment for young SMEs that are more exposed to the costs of failure than larger firms. However, policymakers need to understand, accept and communicate the inherent uncertainty of supporting the private sector in the search for innovation winners. Our results suggest that many government-supported firms may fail to grow or even exit the market. Our doubly robust regression results showed that, for all growth indicators, government financial assistance had no direct, positive impact on firm sales, value-added, profit and employment growth (though we note it did stimulate wage and salary growth).

Coad *et al.* (2018) argue that much of the dynamics we see are age-dependent and Guarascio and Tamagni (2019) provide some evidence that persistent innovation does not drive up growth in the long term after Spanish manufacturers cease their innovating. Even if in the long run growth and innovation persistence is essentially randomized and hard to predict in any single firm, short-term high-growth episodes in aggregate may deliver sustained economic, employment and wage growth in Australia, which we show is driven in part by short-run persistent innovation or innovation spells (Raymond *et al.*, 2010; Capasso *et al.*, 2013; Daunfeldt *et al.*, 2014; Bianchini and Pellegrino, 2019). So, while we agree with Moreno and Coad (2015) that targeting innovation policies to specific firms in the hope that they will drive high growth is impractical, we would argue that successive waves of firms experiencing short-term high-growth episodes, sustained perhaps by broad-based innovation policies, may be a pro-growth economic strategy consistent with the conclusions of Ciriaci *et al.* (2016). The aim of policymakers is not to support any one type of innovation in any one firm (or sector), but to encourage innovation-oriented cultures across all firms (Acemoglu *et al.*, 2018).

Innovation persistence literature suggests that helping firms develop an early innovation orientation or culture is more important to economic success than an ongoing subsidy of specific innovation activities, particularly in older firms that are more likely to shrink than to grow (Le Bas and Scellato, 2014; Navaretti *et al.*, 2014; Máñez *et al.*, 2015). The first five years of consecutive innovation seems to be the most critical to establishing an innovation culture (Triguero *et al.*, 2014). Coupling this with evidence that the most active growth phase of firms is their first five to seven years (Coad, 2018), our data suggest that economic and employment growth may be best served by supporting young SMEs (less than five years old) that are innovating for the first time. Beyond this period, government support may be less effective in stimulating growth via innovation in known persistent innovators or large and mature firms where innovation cultures and resources are already well-established (Peters, 2005).

### Further research opportunities

No study to date has simultaneously observed whether different types of growth (sales or turnover, profit, value-added, productivity and employment) are supported by persistence in different types of innovation (product, process, organizational and marketing) at the same time as accounting for survivor bias. We could not control for survivor bias because of the limitations of our innovation survey and its confidentiality restrictions, but note that persistent Spanish product or process innovators have superior survival rates (Bianchini and Pellegrino, 2019). Survival bias could therefore be partly driving these results (Coad *et al.*, 2018).

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While this study used many indicators to develop a propensity score, a number of our descriptive observations point to control variables that may further reduce omitted variable bias in future innovation persistence and growth studies. While the innovation persistence results are compelling, physical and intangible capital stock information is largely missing from the dataset, making it harder to claim growth is purely driven by sustained inter-firm competitive advantage (Denrell, 2004). Most studies (including this one) do not measure supply chain effects (where one firm's process innovation is another firm's product innovation (Calvino and Virgillito, 2018). Tavassoli and Karlsson (2017) also show that innovation persistence could be stimulated by external regional factors. While our choice of control variables was generally firm-level, some sectoral or market-specific proxy information, such as skill shortages, may account for some of this regional variation. Even strategic management capability which, when measured, accounts for significant variation in firm performance (Peters, 2005; Bloom *et al.*, 2014) could be reflected in variation in organizational and managerial innovation (Hendrickson *et al.*, 2016).

The higher likelihood of complementary and more novel innovations in persistent innovators found in our study also suggests that persistent innovators are more strategic or entrepreneurial than their less persistent counterparts. This would fit with the argument of Audretsch *et al.* (2014) that entrepreneurial firms that can be more adaptive and better exploit knowledge spill-overs will outperform other firms. The regression results showing a strong relationship between firm cooperation and growth support this argument and are consistent with Arranz *et al.* (2019). This further complicates a reverse causality argument. Firm innovation (persistence) may be our best current signal for a successful, strategic firm with higher levels of intangible capital, specifically managerial capital.

The impact of institutional factors on the innovation–growth relationship was not extensively examined in this paper though a number of indicators, such as firm cooperation and collaboration, skill shortages, market competition, foreign ownership and government assistance influenced firm growth rates, depending on the growth indicator studied (see Tavassoli and Karlsson, 2017). Future research could incorporate sequence analysis into our matching method to eliminate confounding patterns of innovation; for example, less frequent innovators who introduced innovations at different ends of the three-year time period (100 *vs* 001 patterns). Innovation-active firms, particularly persistent innovators, tended to be larger within their own size class compared with non-innovators. Other output measures such as annual turnover, are also correlated. Further research needs to include a more continuous variables in the PSM technique, particularly tighter turnover, output and employment ranges to account for these differences. This, along with more modern causal inference techniques that conserve sample size, such as causal forest modelling (see Wager and Athey, 2018), would improve the robustness of the results.

#### **Disclosure statement**

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The results presented here are based, in part, on tax data supplied by the Australian tax office (ATO) to the Australian bureau of statistics under the taxation administration act 1953, which requires that such data are used only for the purpose of administering the census and statistics act 1905. Any discussion of data limitations or weaknesses is in the context of using the data for statistical purposes, and is not related to the ability of the data to support the ATO's core operational requirements. Legislative requirements to ensure privacy and secrecy of this data have been adhered to.

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In accordance with the census and statistics act 1905, the results presented are unlikely to enable identification of a particular person or organization.

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# **RESEARCH PAPER**

# Frugal innovation capabilities: conceptualization and measurement

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#### ABSTRACT

Firms in emerging markets are rapidly developing frugal innovation capabilities (FICs) in order to harness the growth potential of these markets. Researchers have explored this frugal innovation phenomenon through case studies of such firms. This nascent domain of study has been growing, and the demand for a specialized focus on FICs and their measurement is strong. This paper aims to satisfy the demand by conceptualizing FICs using the theoretical framework of dynamic capability, developing a measurement scale, and empirically validating the scale to measure FICs. Data from the medical device and automobile sectors in India were applied for this purpose. It is proposed that FICs are a composite variable with four dimensions: value for money, acceptable quality, scalability and marketability. The confirmatory factor analysis results validate these dimensions, presenting a gateway to explore FICs and their applications.

# Introduction

Emerging markets (EMs) hold within them a plethora of opportunities veiled by a highly turbulent environment (Peng *et al.*, 1999), underdeveloped institutions (Peng and Khoury, 2008), bureaucratic structures, weak intellectual property rights, unclear customer credit assessment and infrastructural bottlenecks (Khanna and Palepu, 2010). The set of opportunities evoked is driven by the rapid growth rates of EMs, resulting in the emergence of a large segment of upwardly mobile consumers at the middle and bottom of the income pyramid (Prahalad and Lieberthal, 1998). The consumer market in EMs in India is expected to reach \$US 6 trillion by 2030 (*Economic Times*, 2019). These consumers demand affordable products with a quality that is comparable with that of market leaders (Zeschky *et al.*, 2011; Bound and Thornton, 2012). De-frilled/de-featured products from developed markets would fail to attract this unique consumer base (Govindarajan and Trimble, 2012). Thus, to capture this trillion dollar market, firms must rethink their innovation agendas.

Firms in EMs are revisiting the drawing board to develop innovative products that are 'good enough', customized to suit local consumer needs in terms of lower costs, portability, fewer/ different features, and ease of usage/maintenance/delivery across geographically fragmented markets. The innovative products in this distinctive class are termed 'frugal innovations' (Wooldridge, 2010; Ronald Berger Consultants, 2014), and a firm's capability to deliver such innovations successfully is its frugal innovation capability (FICs).

In addition to 'frugal innovation', related terms are applied to innovation in EMs – 'Jugaad innovation' (Radjou *et al.*, 2012a), 'inclusive innovation' (George *et al.*, 2012), 'low-end disruptive innovation' (Christensen, 1997), 'resource-constrained innovation' (Ray and Ray, 2010) and 'cost

innovation' (Williams and van Triest, 2009; Williamson 2010). Though there is a tendency to consider frugal as equivalent to cheap, researchers have shown this to be otherwise. According to Harris *et al.* (2020), frugal innovation does not indicate low quality; rather, it means providing the best possible solution within given circumstances and constraints. Further, multinational firms entering EMs are not able to offer products that are already being sold in mature markets and are instead required to redesign their products and create frugal innovations in order to respond adequately to the needs of EMs (Williamson, 2010; Zeschky *et al.*, 2011). For instance, GE had to develop a portable ultrasound machine and a handheld electrocardiogram machine for India and China as their existing American products, even if de-featured, could not be successfully offered in EMs (Zeschky *et al.*, 2011). The COVID-19 pandemic has catalysed the need for frugal innovations, especially in the field of medical devices. Makers Asylum, a makerspace in India, has developed an inexpensive face shield kit priced at INR 55 (\$US 0.73), one-third of the average market price (Radjou, 2020). In fact, to combat the pandemic, EM governments are urging both small entrepreneurs and large companies to develop low-cost ventilators, personal protective equipment, and vaccines that can benefit society at large (Harris *et al.*, 2020).

It is also observed that in order to survive in high velocity and uncertain EMs, such as India (Pandit *et al.*, 2018), firms have continuously to change/rejuvenate themselves, a core tenet of dynamic capabilities theory (O'Connor, 2008). In uncertain environments, building dynamic capabilities requires new situation-specific knowledge, risk taking by company leadership (O'Connor and McDermott, 2004), rapid learning, rough prototyping (Veryzer, 1998) and exploring co-development opportunities (Thongpapanl, 2005). Firms that want to exploit opportunities in EMs recognize that the dynamic capabilities required in the current environment are different from those developed in the past (Eisenhardt and Martin, 2000). Thus, this paper leverages the advances in dynamic capability theory (DCT) to increase our understanding of firms' capabilities to develop frugal innovations. This paper not only uses the DCT framework to explore FICs, but also offers a scale to measure FICs (see Slavec and Drnovsek, 2014).

#### Literature review

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#### Frugal innovation

Frugal innovation is a resource-scarce solution that is designed and implemented in a resourceconstrained environment where the final solution, though significantly less expensive, is still good enough to meet consumer needs (Hossain *et al.*, 2016). Along the same lines, Agarwal *et al.* (2017) define frugal innovation as a good enough quality product for resource-constrained customers. Zechsky et al. (2014) state that frugal innovation involves higher technical novelty and market novelty than good enough innovations. Tiwari and Herstatt (-2012) posit that frugal innovations seek to create valuable offerings for their targeted customer by focusing on core functionalities, thus minimizing the use of material and financial resources while fulfilling or even exceeding prescribed quality standards. Bhatti and Ventresca (2013) adopt an input-output view and define frugal innovation as 'a means and ends to do more with less for more people'. Emphasizing the nature of frugal innovation, Krishnan and Jha (2011) advocate that such innovation responds to limitations in resources, whether financial, material, or institutional, and turns these constraints into advantages. Furthermore, the authors propose that frugal innovations can lower costs by minimizing the use of resources in development, production and delivery, or by leveraging them in new ways. Frugal innovations that have been successful are not only lower in cost, but also outperform the alternative and are largely scalable (Krishnan and Jha, 2011). The economic use of raw materials, reuse of components and simpler designs in frugal products, compared with their ordinary counterparts, ultimately have a positive impact on sustainability as well (Rao, 2013). Other researchers look at the export capabilities of frugal innovations and define frugal innovation as an 'innovative, lowcost, and high-quality product originating in developing countries and exportable to the developed

world' (George *et al.*, 2012). Bringing together these disparate pieces of definition for the purpose of this study and data collection, we characterize frugal innovators as those who seek to create attractive value propositions for targeted customer groups by focusing on core functionalities and thus minimizing the use of material and financial resources in the complete value chain. They substantially reduce the cost of usage and/or ownership while fulfilling or even exceeding prescribed quality standards.

Both industry examples and past research have shown that frugal innovations are better suited for rugged environments with resource constraints. Further, it is observed that EMs with large rural communities demand frugal innovations (Pisoni et al., 2018). For example, to serve rural consumers, Godrej & Boyce, an Indian firm, developed an affordable refrigerator - ChotuKool that performed under conditions of intermittent power supply (Kuo, 2017). A few studies that have examined such frugal innovations in EMs have done so through the lens of the theory of lead markets. A lead market has been defined as a country/market where the innovation is first successfully accepted, adopted and later diffused to other nations (Beise and Gemünden, 2004). Hossain et al. (2016) propose four patterns of diffusion for frugal innovations – local, proximal, distance and global. Local diffusion indicates that the diffusion is contained within a limited geographic region. For example, Mitticool, a clay-based refrigerator, has not diffused beyond Gujarat, a state in India. Proximity diffusion occurs when a frugal innovation diffuses to neighbouring nations with similar socio-economic conditions. For example, the Tata Ace, a sub-one-ton mini truck manufactured by an Indian company (Tata Motors Limited) was designed to navigate through the narrow and crowded Indian roads, provide better safety and comfort than the existing three-wheeled vehicles and be available at an affordable cost. This was exported to the neighbouring country of Sri Lanka, which shares similar physical/economic conditions (Tiwari and Herstatt, 2012). Distance diffusion is when a frugal innovation spreads to neighbouring as well as to distant nations. Vortex Gramteller, an automatic teller machine (ATM) that runs on solar energy, was developed in India to address the paucity of ATMs in rural regions, typically plagued by unstable power supply and non-existent climate-controlled locations. This low-cost frugal innovation (\$US2,400 vs. \$US14,000 for a conventional powered ATM) has spread to such neighbouring nations as Bangladesh, Bhutan and Nepal as well as parts of Africa with similar socio-economic and climatic conditions, but not to developed nations.

Lastly, global diffusion is when frugal innovation diffuses in all of the above three ways and also spreads to developed nations with different socio-economic conditions. Mahindra & Mahindra, an Indian firm, invented the low-cost mini tractor, Yuvraj, to meet the requirements of small and marginal farmers owning less than five acres of farmland (Bera, 2018). The motivation to create this frugal innovation lay in the fact that only 1% of small and marginal farmers in India had access to a tractor because of the small size of their farm holdings. And no existing mechanized farming solutions met their needs. This frugal innovation is currently being exported to the United States to meet the needs of backyard and hobby farmers (Hossain, 2018). Based on all of the Indian examples indicated, researchers have rightly concluded that India is a hotbed of, and a lead market for, frugal innovations (Herstatt *et al.*, 2008; Govindarajan and Trimble, 2012).

# Dynamic capability theory and innovation capability

Dynamic capability theory (DCT) has its roots in resource-based theory (RBT), which postulates that firms are a bundle of heterogeneous resources, capabilities and attributes (Barney, 1991). These attributes are hard to modify (Amit and Schoemaker, 1993; O'Connor, 2008), leading RBT to claim that a firm's competitive advantage comes from the exploitation of existing firm-based assets. However, further research argues that such assets may no longer be sufficient to maintain competitive advantage during rapid changes because, in dynamic markets, the strong focus on core resources may create rigidity (Leonard-Barton, 1992) and impede the firm from adapting its resources to new

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competitive environments (Zhou and Li, 2010). This necessitated the extension of RBT to assess a firm's resource configuration in dynamic environments to gain sustained competitive advantage. This, in turn, led to DCT emphasizing the role of dynamic capabilities in adapting, integrating and reconfiguring firm assets to align with the requirements of the changing environment (Teece *et al.*, 1997). Dynamic capabilities have been described as a combination of the capacities to (a) sense and shape opportunities, (b) seize these opportunities and (c) maintain competitiveness through enhancing, combining, protecting and, when necessary, reconfiguring the business enterprise's intangible and tangible assets (Teece, 2007). In order to gain sustainable competitive advantage, especially in EMs which are characterized by high volatility and complexity (Khanna and Palepu, 2010), firms require dynamic capabilities to sense and seize market opportunities (Dixon *et al.*, 2010). In other words, firms have to build on the 'innovation function of dynamic capabilities', going beyond the mere utilization of existing capabilities (Dixon *et al.*, 2010) and seeking fresh ways to capitalize on the knowledge gained in EMs (Kogut and Zander, 1996).

Akman and Yilmaz (2008) define the aforementioned innovation function of dynamic capabilities as one that facilitates an innovative organizational culture and promotes internal activities and capabilities to understand and respond appropriately to the external environment. Adler and Shenbar (1990) define innovative capability as the capacity to respond to unexpected opportunities created by a dynamic competitive environment. Sher and Yang (2005) emphasize the importance of dynamic environments in highlighting how innovation capability works, stating that firms possessing such capability successfully integrated strategically relevant resources to drive innovation and maintain competitiveness (Lawson and Samson, 2001). Greeven (2009) incorporates all of the above and defines innovation capability comprehensively as the 'ability of a firm to integrate, build, and reconfigure internal and external critical resources to develop and successfully commercialize new products and services', thereby firmly rooting the definition in DCT. In line with such thinking, evidence from businesses operating in EMs shows that firms actually embrace frugal innovation in order to tap into a growing and aspiring middle class while simultaneously addressing the challenges of a volatile environment (Tiwari and Herstatt, 2012; Hossain, 2018). Such companies as Godrej-Boyce with its ChotuKool portable refrigerator, Mahindra & Mahindra with the Yuvraj mini tractor, Vortex Engineering with Vortex Gramteller ATM, and GE with its Lullaby baby warmer are just a few examples of successfully adopted frugal innovations addressing the needs of the emerging Indian market.

#### Frugal innovations in India – the critical context

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India is a source of several frugal innovations (Prahalad and Mashelkar, 2010). Indian markets, characterized by large, young populations with lofty aspirations and limited budgets, have several industrial sectors providing frugal products that are versatile, affordable, robust and good enough in terms of quality (Chakravarti, 2006; Tiwari and Herstatt, 2012). Firms in the medical devices and the automobile sectors have produced several commercially successful frugal innovations (Deloitte, 2016; Tiwari and Phadnis, 2017).

The Indian medical devices sector ranks fourth in Asia with respect to market size and is expected to reach \$US25–30 billion by 2025 (Deloitte, 2016). This growth will be propelled by a heightened demand for healthcare, especially in the areas of endocrinology and cardiac health. India has the highest incidence in the world of diabetes, coronary heart disease and obstructive pulmonary disease, which are currently leading causes of mortality. Additionally, rising disposable incomes and wider medical insurance coverage are driving up the demand for, and utilization of, healthcare services (Deloitte, 2016), indicating a substantial hitherto untapped market that could be well served by developing frugal and robust medical devices. India has emerged as a hub for some of the most innovative and entrepreneurial healthcare solutions in the last decade, such as GE's portable handheld ECG machine (Rosenfled, 2014). Some of these frugal products have developed niche markets

in many regions globally (Deloitte, 2016). For instance, 3nethra's digital non-mydriatic fundus camera, which eliminates waiting time for pupil dilation, has been approved by the food and drug administration in the United States and is Health Canada registered. Hailed as an innovation capable of eradicating preventable blindness, it is being used in glaucoma testing in both countries, proving that India-originated frugal technology solutions can be of high quality and built for affordability/ accessibility (IAPB, 2020).

India's automobile sector has also seen an exponential growth in frugal innovations. This sector is expected to grow to \$US300 billion by 2026 (Gupta *et al.*, 2018) fuelled by increasing domestic demand for low cost automobiles, a competitive value chain, low labour costs and a strategic geographic location (Ernst & Young, 2016). There is an enhanced focus on low-cost manufacturing capabilities while simultaneously meeting customer expectations for price and performance (Prabhu *et al.*, 2012).

Even though the Tata Nano car was a commercial failure, it was a pioneer frugal innovation which retailed at \$US1,500. Designed not to attract a car buyer, but to replace a two-wheeler, it was intended to provide an affordable and safe alternative for the Indian family that typically travelled unsafely on a motorbike (Sharma, 2017). Since then, the automobile sector has seen several frugal innovations in many vehicle categories (e.g., pick-up trucks such as Tata Ace at \$US5,000; Ashok Leyland-Nissan's Dost at \$US6,600; cars such as Renault-Nissan's Logan at \$US10,000; tractors such as Mahindra's Yuvraj at \$US3,500) (Radjou *et al.*, 2012b). Several of these frugal innovations are also set to be sold globally. For instance, Renault-Nissan's global small car, priced at \$US5,200 is to be commercialized in India and then introduced in other emerging markets such as Brazil, Indonesia and South Africa (Radjou *et al.*, 2012b). Automobile industry experts describe frugal innovation in terms of not just the mindset, but also the process capabilities that allow them to innovate under constraints and turn adversity into growth opportunities (Radjou *et al.*, 2012b).

### Methodology

When new constructs are developed based on separate domains of literature, and the outcome leads to new measures, a mixed methods methodology combining both qualitative and quantitative research efforts is recommended (Edmondson and McManus, 2007; Ang, 2014). Since our study aims to develop a new measure for FICs by bringing together existing and disparate areas of literature from distinct areas, we also adopted a combination of qualitative and quantitative research methods (Johnson *et al.*, 2007). The qualitative phase is followed by the quantitative phase.

# Conceptualizing and defining FICs

To conceptualize and define frugal innovation capability, we adopt a sequential methodology similar to that used by Bhatti and Ventresca (2013). The steps include (1) collating multiple definitions available in the literature for the two components of FICs (i.e., frugal innovation and innovation capability); (2) deriving core themes from the existing definitions through content analysis; (3a) creating two working definitions of FICs by combining the relevant themes extracted from step 2; (3b) then presenting core themes to academics to create two more working definitions; (4) arranging for a different set of experts and academics in the field to combine the four definitions generated in step 3 to create a single working definition for FICs; (5) obtaining validation of this definition from both medical devices experts and automobile industry experts; and (6) lastly, modifying our working definition with experts' inputs to create the final definition for FICs that guided the rest of our research. These steps are documented in Figure 1.

Definitions of frugal innovation (Wooldridge, 2010; Bhatti and Ventresca, 2013; Tiwari *et al*, 2016) and innovation capability (Martinez-Román *et al.*, 2011) from past research were subjected to content analysis. Six relevant themes (e.g., resource constraints) for frugal innovation and

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seven core themes (e.g., capability to respond to the dynamic environment) were extracted. These themes were used by the researchers to develop two working definitions while the themes were simultaneously presented to fellow academics to create two additional working definitions of FICs. Next, these four working definitions were presented to six academics in the field from accredited business schools in India and the United States. From the input received, a single synthesized definition for FICs was developed as:

The capability of an organization to explore new concepts and generate marketable and scalable low-cost acceptable quality product/service solutions in a resource-constrained environment by applying combinations of available resources to respond to market opportunities.

Next, the definition was subjected to face validity testing through semi-structured interviews of industry experts from the medical devices and automobile sectors in India. Experts chosen through referrals were busy top management executives who preferred shorter interviews with pointed questions and high clarity. These executives from medical devices and automobile firms were located primarily in the cities of Bengaluru and Chennai. Bengaluru is a leading hub in India for technology-based medical devices (SKP Business Consulting, 2016), while Chennai leads in the automobile sector and is often referred to as the Detroit of South Asia (Ramanathan, 2008). As there were no publicly available databases with executive names/contact information, we used the professional platform LinkedIn to connect with a network of senior executives. LinkedIn profiles helped identify the right executives for the interviews where the respondents had a minimum of five years of experience in a C-level/product development/product management/leadership role. Once an executive respondent was identified, an introductory message with the purpose of the study, the broad area of research and a request for an interview was sent. Executives typically replied within 72 hours, and the positive response rate was 64%. A total of 16 interviews (nine from the medical devices sector and seven from the automobile sector) were conducted. Selected excerpts from the interviewer's opinions of our definition are presented next (editorialized for clarity):

It is a great (definition) and encompasses all the things (aspects). It talks about resource constraints, scalability, quality, affordability, putting together resources in a meaningful way and see to how this can work in a robust user-friendly way in the market. That is exactly what your definition addresses. I think it (the definition) really addresses all these (aspects). (Expert 2, medical devices sector)

Cost effective is fine, but using 'low cost' seems inappropriate. So, exclude (or replace) low cost from (in) the definition. (Expert 4, automobile sector)

Instead of low cost, value-added products (value for money), or cost effective would be a better way of saying this. (Expert 10, medical devices sector)

Generally we look at what others are doing (producing), and we repeat the same (but) it is not a good thing for us to do. Your definition is very appropriate. (Expert 6, medical devices sector)

Most of the experts opined that the term 'low cost' in our working definition wrongly portrayed frugal innovations as make-do products with cheap quality, sub-par functionality and minimal effort spent in designing them. In contrast, frugal innovations demand that the innovating team of engineers, designers, scientists, market experts and other firm leaders design the product from scratch in conjunction with a thorough understanding of customer needs and product functions. The experts suggested using the terms 'cost effective' or 'value for money' instead of 'low cost'. We therefore replaced 'low cost' with 'cost effective' in our final definition of FICs. Our modified definition of FICs henceforth reads:



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Figure 1. Conceptualization process of FIC

The capabilities of an organization to explore new concepts and generate marketable and scalable cost effective, acceptable quality product/service solutions in a resource-constrained environment by applying combinations of available resources to respond to market opportunities.

# Measuring FICs

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To develop the measure of frugal innovation capabilities, a scale-development process suggested by Slavec and Drnovsek (2014) was adopted. The first step of construct conceptualization is addressed in the previous section. The next step was to operationalize the indicators or items to measure the different dimensions of our FIC construct (DeVellis, 2016). Several reflective indicators (derived from our definition) contribute to the underlying construct and represent the different dimensions of FICs. To measure FIC, a uniform five-point Likert scale (1=strongly disagree to 5=strongly agree) was used (Li, 2013). Based on our definition, we propose that the FIC is a second-order firm-level construct comprising four first order dimensions: value for money, acceptable quality, scalability and marketability.

• Value for money (vm) (cost effective): defined in the Cambridge Dictionary as 'cost effective' as 'good value for the amount of money paid' or value for money. Industry experts suggested the term 'low-cost' be replaced with 'cost-effective' or 'value for

money'. To avoid any negative connotations of low quality/functionality, the term 'value for money' will be used in this paper. A literature-based definition of value for money might be the most favourable combination of lifecycle costs, quality of goods/ services to satisfy consumer requirements (Morallos and Amekudzi, 2008). Lifecycle costs to the consumer include monetary, temporal, energy and psychological outlays in addition to the expenses incurred in evaluating, obtaining, using and disposing of an offering (Kotler *et al.*, 2013). When evaluating the value for money of frugal innovation, consumers compare lifecycle costs with non-frugal alternatives on the market, provided the frugal product also exhibits an acceptable level of quality (Hossain, 2018). Three items (see Appendix 1) were developed to measure the dimension of value for money.

- Acceptable quality (aq): defined in the literature as something like the minimum level of user requirements that fulfils user expectations and needs as part of user experience (Jumisko-Pyykko *et al.*, 2008). It is the threshold level of quality below which the consumer would not accept the offering (Dumicic *et al.*, 2006). To measure acceptable quality, four items were created, based on the dimensions of quality proposed by Garvin (1987).
- Scalability (sc): referring to the ability of an organization to maintain or even increase production, sales, revenues, operational and human efficiencies when tested by larger market demands in a short period of time, while simultaneously lowering marginal costs of each additional unit produced (Dudnik, 2010; Angel Investor Report, 2021). When a firm evidences the ability to scale up successfully, the firm is capable of increasing several firm metrics without requiring additional investments in human resources (Angel Investor Report, 2021), capital (Vyge, 2013) or operational expenditure (LeBlanc, 2019). Based on this discussion, five items were developed to measure scalability.

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• *Marketability (mkt)*: indicating whether a frugal product will appeal to buyers at a certain (affordable) price point generating a profit for the firm (*Chron*, 2020). Even if the frugal product is more affordable at a lower price compared with prevailing maturemarket offerings, this affordability factor would still sustain consumer trust in the quality of the product (Radjou, 2020). Further, the frugal product will be perceived by the market to be desirable/appealing and 'capable of fulfilling or even exceeding acceptable quality standards' (Weyrauch and Herstatt, 2016). Based on this discussion of market appeal, comparable quality, and consumer trust in quality, three items were developed to measure marketability.

An initial item pool of 15 items (Appendix 1) was created to measure FICs and tested for content validity, which is the next step of scale development. Content validity, defined as 'the extent to which measurement items represent a proper sample of the theoretical content domain of a construct' (Nunnally and Bernstein, 1994), is typically ascertained by experts/ judges (Hardesty and Bearden, 2004). The 15 items were presented for review to six experts/ judges who either had high familiarity with the term 'frugal innovation' or were involved in the research/sales of frugal innovations in the two industries in our study (Hardesty and Bearden, 2004). Judges comprised faculty from business schools, consultants and practitioners from the medical equipment and automobile sectors, and physicians. Feedback from the judges was examined, and the inter-judge content validity ratio (CVR) (Lawshe, 1975) was calculated to quantify consensus (see Appendix 3). The average CVR achieved was 0.932, above the 0.80 cutoff for content validity. In the validity literature, achieving 0.80 agreement is the threshold for having confidence in the instrument items when ascertaining content

Table 1. Descriptive	statistics	of the sample	;
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Descriptive	Frequency (n=121)	%
Sector		
Medical devices	93	76.9
Automobiles	28	23.1
Major locations		
Bengaluru	51	42.1
Chennai	18	14.9
Mumbai	10	8.3
Delhi	7	5.8
Gurgaon	7	5.8
Legal entity		
Sole proprietorship	4	3.3
Private limited company	103	85.1
Public limited company	14	11.6

validity through expert judges (Newman *et al.*, 2013). The final measurement instrument, including the above-mentioned validated items and additional demographic questions, is provided in Appendix 2.

### Sampling and data collection

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For this research, we adopted purposive sampling, where the respondents are chosen because of a desired set of characteristics they possessed, which best enabled them to answer the research questions we posed (Etikan et al., 2016). A purposive expert sample is a type of nonprobability sample assumed to be representative of the population because researchers apply their expert knowledge of the population to select in a nonrandom manner a sample of respondents that best represents a cross-section of the population (Lund Research, 2012). Further, purposive expert sampling is recommended when researchers are pursuing a mixed methods research design and need to gain knowledge from individuals who have particular expertise. Application of the technique 'is not considered to be a weakness' (Etikan et al., 2016). The population of interest included experts from the medical devices companies listed in the database maintained by the central drug standard control organization and ten large companies in the automobile (passenger vehicles only) sector in India (Shah, 2017). The 412 experts approached typically occupied executive level positions including MD, CEO, SVP/EVP/VP, founder, president and chairman. Positive contact via LinkedIn was made with 174 senior executives, and 121 respondents completed the questionnaire with a response rate of 69.14%. In purposive expert sampling, a response rate of 60% or greater is considered to be optimal because nonresponse bias is thought to be minimal with higher response rates (Fincham, 2008). Descriptive statistics of the respondents are presented in Table 1.

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#### DATA ANALYSIS AND RESULTS

#### Factor analysis

Factor analysis is the primary statistical technique used (1) in psychometric evaluations of multi-item measurement instruments, such as surveys (Nunnally, 1978), and (2) in validation of new constructs by demonstrating that measurement items load on to underlying factors in anticipated ways (Gorsuch, 1983) and (3) in reducing data by compressing intercorrelated items into factor scores for use in further analysis (Thompson, 2004). Factor analysis is based on the seminal work of Thurstone's (1947) common factor model, which suggests that each item in a measurement instrument is a linear function of one or more common factors and one unique factor. Factor analysis thus separates the common variance, the unique variance and the random error variance in order to extract the unique latent factors underlying the observed indicators. According to Kim and Müller (1978), there are two main types of analyses: exploratory factor analysis (EFA) (Spearman, 1904) and confirmatory factor analvsis (CFA) (Jöreskog, 1969). EFA is the first step in dimension-reduction and is used during scale development to identify the latent factors (Slavec and Drnovsek, 2014). EFA is data-driven and no a priori specifications are made in regard to the number of latent factors or to the nature/magnitude of the item factor loadings. On the other hand, CFA (which follows EFA) requires prior specification of the number of factors, the factor loadings and the variances. The researcher uses metrics<sup>1</sup> to determine how well CFA reproduces the covariance matrix of the measured variables in order to evaluate the factor model proposed by EFA.

### Exploratory factor analysis

Frugal innovation capabilities (FICs) is a new construct; hence, we used factor analysis to identify the factors/dimensions that comprise FICs. Typically, EFA requires several measured variables (items) and researchers have suggested varying numbers of individual items – ranging from two to five – that would load on to each latent factor (MacCallum *et al.*, 1999). Though there are scales in the psychology literature that contain only two items per factor, a minimum of three items loading onto each factor is usually recommended, as this number will yield convergent solutions in CFA that would typically follow EFA (Marsh *et al.*, 1998).

To check the applicability of EFA for the data, a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity was tested. The KMO measure of sampling adequacy is a statistic that indicates the proportion of variance in measurement variables which might be caused by underlying latent factors. It ranges between 0 and 1, and tests whether partial correlations between variables are sufficiently small. It has been suggested that, though a KMO measure greater than 0.5 is acceptable, a measure >0.8 is *meritorious* and will yield satisfactory factor analysis (Kaiser, 1970; Kaiser and Rice, 1974). The KMO value obtained with our data was 0.84, confirming that the proportion of common variance is low and that our data are suitable for EFA. We next conducted Bartlett's test of sphericity to ensure that the correlation matrix of our variables diverged significantly from an identity matrix. More specifically, the p-value from Bartlett's Test of Sphericity was lower than our chosen significance level (p=0.05), thus confirming that our data were suitable for EFA.

We applied principal component analysis (PCA) as the method of extraction for the underlying factors in EFA. PCA is a dimensionality-reduction technique that effectively reduces a large dataset of variables into a smaller one while keeping intact/preserving most of the information in the larger dataset (Jolliffe and Cadima, 2016). The new latent variables (unnamed principal components) are constructed as linear combinations of the initial variables, which are compressed into

<sup>&</sup>lt;sup>1</sup>Such as GFI, NFI, TLI, RMSEA and CFI (to be discussed later).

		Comp	oonents	
	1	2	3	4
vm1				0.800
vm2				0.787
vm3				0.698
aq1		0.813		
aq2		0.785		
aq3		0.834		
aq4		0.817		
sc1	0.881			
sc2	0.928			
sc3	0.896			
sc4	0.878			
sc5	0.770			
mkt1			0.848	
mkt2			0.882	
mkt3			0.795	

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 Table 2. Rotated component matrix of FIC

Notes: Extraction: PCA

Rotation: Varimax

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Kaiser-Meyer-Olkin measure of sampling adequacy: 0.848

Bartlett's test of sphericity: 0.000

these new variables still preserving most of the information (Jolliffe and Cadima, 2016). Significant eigenvectors, computed from the covariance matrix, that account for most of the variance (>60%) (Hair *et al.*, 2014, p.112) and identified from corresponding higher eigenvalue s (factor loadings of at least |0.4| (Stevens, 1992)) help indicate the underlying factor structure. According to Kaiser (1960), factors with eigenvalue of greater than 1 have to be retained. We find four distinct factors with eigenvalues greater than 1 that explain more than 78% of the total variance. Table 2 lists all 15 items and summarizes the results by providing the dominant loading for each item. Upon varimax rotation, a clear factor structure was observed (see Figure 2) and all the factor loadings were greater than 0.6. The four distinct factors were labelled as 'value for money', 'acceptable quality', 'scalability' and 'marketability'.

# Confirmatory factor analysis and assessing model fit

Analysis of moment structures (AMOS) was used to conduct CFA. The results of the CFA model are presented in Figure 3, depicting FICs with its four factors (value for money, acceptable quality, scalability and marketability), along with their respective observed variables (15 items). Finally, reliability, average variance extracted and discriminant validity were examined.

We hypothesized a four-factor model to be confirmed in the measurement portion of our analysis. After confirming the absence of univariate/multivariate outliers and variable normality through SPSS, we conducted CFA in order to confirm the factor structure by hypothesizing *a priori* the four factors expected separately, and by constraining each item to load on one (and only one)

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Figure 2. Component plot in rotated space

factor and setting all cross-loadings to zero. Assessment of fit indices are below; and the theoretical model is presented in Figure 3, where larger circles represent latent factors, rectangles represent measured variables/items and lines represent the connections. In CFA, it is assumed that the latent factors may not completely explain the variance, hence the error terms (e1 to e15, in smaller circles) are connected with each corresponding observed variable. Specifically, the model fit is evaluated based on certain suggested parameters. The ratio of chi-square over the degrees of freedom (CMIN/ DF) is 1.77, which is lower than the threshold value of 3.0 (Hair *et al.*, 2006). The goodness-of-fit index (GFI) which indicates the proportion of variance accounted for by the estimated population covariance and analogous to  $R^2$  is 0.86, higher than the recommended 0.8 (Forza and Filippini, 1998; Greenspoon and Saklofske, 1998). The normed fit index (NFI) is 0.9, which is in line with the recommended threshold of 0.9 (Hair et al., 2010). An NFI of 0.9 indicates that our model of interest improves the fit by 90% relative to the null model. The comparative fit index (CFI), a revised form of NFI which compares the fit of our model to the fit of a null model, is 0.95, higher than the prescribed threshold of 0.9 suggested by Hair et al. (2010). The root mean square error of approximation (RMSEA), a parsimony-adjusted index where values closer to 0 represent a good fit, is 0.08, lower than the 0.10 suggested by Hair et al. (2010). NNFI, an index often reported for smaller samples and called the Tucker Lewis index (TLI), is 0.94, which is higher than the recommended value of 0.9 (Forza and Filippini, 1998; Awang, 2012). The values of model fit parameters indicate a good fit between our model and the observed data.

### Assessing reliability and validity

To evaluate the psychometric properties of reliability and construct validity, we compared several metrics produced by our data analysis against suggested thresholds. The composite reliability (CR) values for each of the factors (see Table 3) are higher (range from .71 to .93) than the recommended value of 0.6 (Hair *et al.*, 2017), indicating satisfactory reliability. To establish convergent validity, the values of the average variance extracted (AVE) are considered. The AVE values, ranging from 0.46 to 0.79, are higher than the recommended value of 0.4 (Gefen *et al.*, 2000; Huang *et al.*, 2013), indicating satisfactory convergent validity. Convergent validity is also confirmed from the item loadings. The item loadings from 0.57 to 0.93 (see Table 3) are all above the recommended value of 0.5 (Hair *et al.*, 2009).

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Figure 3. Model: output of CFA

Table 3.	Convergent validity and reliability assessment	

Dimension	Item code	Item loadings	AVE	Composite reliability
Value for	VM1	0.84	0.46	0.71
money	VM2	0.60		
	VM3	0.57		
Acceptable	AQ1	0.93	0.68	0.89
quality	AQ2	0.90		
	AQ3	0.76		
	AQ4	0.68		
Scalability	SC1	0.80	0.73	0.93
	SC2	0.88		
	SC3	0.89		
	SC4	0.91		
	SC5	0.79		
Marketability	MKT1	0.87	0.79	0.92
	MKT2	0.92		
	MKT3	0.88		

To establish discriminant validity, the diagonal in Table 4 represents the square root of the AVE of each construct, and the non-diagonal elements represent the correlation between the latent variables. The square root of the AVE for each construct, represented by the bold elements in Table 4, are higher than its correlation with other constructs (Hair *et al.*, 2006), indicating satisfactory discriminant validity. This evaluation of discriminant validity is based on the Fornell-Larcker criteria (Fornell and Larcker, 1981), where the AVE of each latent construct needs to be greater than its highest squared correlation with any other latent construct. In a second test to assess discriminant validity, the values of the AVE have to be higher than the maximum-shared variance (MSV) (Hair *et al.*, 2006; Alumran *et al.*, 2014). The results from Table 5 indicate AVE higher than MSV, displaying satisfactory discriminant validity. Finally, the difference between the factor loadings and the cross loadings of each item are greater than 2.0, showing additional evidence of discriminant validity (Bagozzi and Phillips,1982) and establishing the strength of the psychometric properties of the FICs scale.

#### Discussion

Looking ahead, emerging markets are expected to have a greater impact on global trade than industrialized nations (Shivdas and Sivakumar, 2013). China, labelled an emerging market two decades ago, is now the second largest economy and the largest exporter in the world (Blazyte, 2020). Emerging economies are not only impacting world trade, they are also poised to surpass developed nations. For example, India overtook the United Kingdom (after Brexit, so GDP does not include the EU market) in 2017 (Gramer, 2019) with its rapid growth in the past decade. Today, EMs account for 36% of global trade, but MNCs that operate in EMs earn only 17% of their revenue from these countries (Atsmon *et al.*, 2012). It has been suggested that the few organizations that are successful in EMs are doing well because they have adopted a frugal innovative mindset and have developed associated capabilities (Mahmood *et al.*, 2014). Economic growth in emerging markets should be spurred on by increased spending on infrastructure (Mauro, 2017), investment in R&D (Inekwe, 2014), expansion of innovation capabilities (Govindarajan and Trimble, 2012) and capital

	Value for money	Acceptable quality	Scalability	Marketability
Value for money	0.68			
Acceptable quality	0.61	0.82		
Scalability	0.20	0.30	0.85	
Marketability	0.41	0.63	0.42	0.89

Table 4. Discriminant validity assessment based on Fornell-Larcker criteria

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lable	). A	Iternate	method	to	assess	d1:	scri	minan	t va	110	111	

Dimension	AVE	MSV	Is AVE > MSV
Value for money	0.46	0.37	Yes
Acceptable quality	0.68	0.39	Yes
Scalability	0.73	0.17	Yes
Marketability	0.79	0.39	Yes

(Woetzel *et al.*, 2018). To remain relevant and competitive in EMs, firms need to employ a revolutionary approach to innovation at the local level, taking a fresh look at developing the right capabilities across their value chains, including sustainable and scalable product innovation (Mahmood *et al.*, 2014; Shivdas and Chandrasekhar, 2016).

While research has explored the nature of frugal innovation (Tiwari and Herstatt, 2012; Bhatti and Ventresca, 2013; Radjou and Prabhu, 2015), there is less understanding of the innovation capabilities required to tap into these emerging markets (Sharmelly and Ray, 2018). We seek to remedy this by developing and validating a FIC scale. Even recent papers on measuring innovation capabilities focus on the service industry (Hogan *et al.*, 2011), exporting firms (Vicente, Abrantes and Teixeira, 2015) and on innovation in general (Calik *et al.*, 2017), but not on FICs. This paper not only conceptualizes FICs and examines their constituent dimensions, it also specifically addresses this gap by providing a validated measurement scale for FICs.

There is appreciation of the need for new measurement and calibration of innovation at the industry level (Gann and Dodgson, 2019), but not at the firm level. Any measurement of a firm's innovation capability should be able to 'assist management in assessing priority innovation areas that need to be addressed, and allow them to respond to challenges posed by the types of innovation capability that need to be improved' (Hogan et al., 2011). This paper provides exactly this by developing a measure of FICs and its dimensions to be used at the firm level. The wide applicability of this particular measure is enhanced at this scale by pooling concepts from multiple domains evident in the four FIC dimensions: marketing (marketability and value for money), operations management (acceptable quality) and business strategy (scalability). Clean factors generated from EFA and satisfactory CFA results, accompanied by successful reliability and validity outcomes, provide an opportunity for the widespread adoption of this FIC scale across various domains. Further, these dimensions find support in several studies on frugal innovation; for example, affordability (Prahalad, 2010; Nakata and Weidner, 2012), value for money and quality (Gadiesh et al., 2007; Radjou and Prabhu, 2015; Sharmelly and Ray, 2018) and acceptable quality (Brem and Wolfram, 2014). Our measure of FICs is thus a holistic composite based on theory but with broad practical relevance.

FICs, rooted in dynamic capability theory, seek to integrate, build and reconfigure internal resources and capabilities. As a part of developing FICs, firms are involved in the forming the multidisciplinary teams required for the development of a frugal product, developing external competencies by collaborating with experts, universities, research centers, venture capitalists and government agencies to develop specialized capabilities. At the institutional policy level, in several EMs that desire freedom from dependency on global supply chains, there is a concerted push for self-sufficiency. For example, the government of India is encouraging innovation by funding collaboration among government, for-profit corporations and academic/research institutions. Labelled *atmanirbhar*, the initiative is expected to see investments of \$US500 billion in selected industrial sectors (e.g., medical services) (*The Hindu*, 2020) with a focus on promoting frugal innovation and developing entrepreneurial ecosystems.

At the firm level, the FIC measure can provide managers with better understanding of how to build innovation capability. Any measure of a firm's innovation capability should be able to guide management in assessing priority innovation areas, revealing deficiencies and assisting them in responding to challenges. Our measure, which neatly partitions FICs into various factors, provides the opportunity to develop industry-specific benchmarks for each of the dimensions, evaluating firm performance against the benchmarks. Such quantification can help companies to assess their strengths and weaknesses *vis-à-vis* competition and to develop corrective strategy, such as training programmes for employees (Kaplan, 2018).

Increasing disposable incomes is driving consumer aspirations in EMs. Firms able to take advantage of frugal innovative capabilities are better able to serve a demanding population and harness the demographic dividend. Satisfying a younger population (over 500 million middle class

consumers in India with an average age of 28) (*Consultancy Asia*, 2019) that wants to ape Western lifestyles but with limited budgets, requires companies that will innovate and offer affordable, high-status products. Firms such as Hyundai India with the Hyundai Eon (Sharmelly and Ray, 2018), and Mahindra & Mahindra with its Kwid automobile (Crabtree, 2015) have successfully ingrained frugal innovation practices into product design and development.

This paper offers a framework for future quantitative studies of frugal innovation. Our FIC scale is currently limited by being tested in only two industrial sectors and in only one emerging market. Future research might extend this to other sub-sectors of healthcare, such as screening, diagnosis, treatment, reparation, patient monitoring and healthcare delivery/access (Swissnex, 2016). It might also test applicability in industries paying increasing attention to frugal innovation; for instance, the advanced electronics sector (especially firms in the defense and space exploration industries), and where firms are beginning to practise stringent cost-effective regimes, which imply a stronger involvement in frugal innovation (Sahay, 2014; Economic Times, 2020). An extension of this research to other EMs could reveal potential insights that can be harnessed by firms for competitive effectiveness and market relevance. Additionally, comparisons between MNCs serving a global population versus localized firms catering to a single demographic could lead to interesting results with policy/strategy implications. The application of the FIC scale requires further investigation in other countries/contexts/industries. Since recent frugal innovation examples come from defence (IDEX4Fauji) (Economic Times, 2020) and space research (India's ISRO Mars orbiter mission, Mangalyaan) (Sahay, 2014), assessing the applicability of the FIC scale in these sectors would seem to offer promising returns.

#### **APPENDICES**

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Dimension	Label	Item description
Value for money	VM1	The price and the acquisition cost (other than price – e.g., delivery charges, service charges, search time, installation costs) of our product are less than prevailing market offerings
	VM2	The maintenance cost of our product is less than prevailing market offerings
	VM3	The production cost is less than prevailing market offerings
Acceptable	AQ1	Performance of our product is comparable with prevailing market offerings
quality	AQ2	Features of our product are comparable with prevailing market offerings
	AQ3	Durability of our product is comparable with prevailing market offerings
	AQ4	Conformance to specifications and industry standards of our product is comparable with prevailing market offerings
Scalability	SC1	We have the ability to increase production volume without incurring significant fixed costs
	SC2	We have the ability to increase sales volume without incurring significant variable costs
	SC3	We have the ability to expand our operations without incurring significant marginal costs
	SC4	We have the ability to increase our revenues without incurring substantial marginal costs
	SC5	We have the ability to grow without incurring significant human resource costs
Marketability	MKT1	Our customers perceive our product to be as appealing as prevailing market offerings
	MKT2	Our customers perceive our product to have quality comparable with that of prevailing market offerings
	MKT3	Our customers perceive our product to be as trustworthy as prevailing market offerings

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Appendix 1. Item pool of FIC

Appendix 2. QuestionnaireFor each statement, please select the option that best suits your organization.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The price and the acquisition cost (other than price – e.g., delivery charges, service charges, search time, installation costs) of our product are lower than prevailing market offerings	1	7	ς,	4	5
The maintenance cost of our product is less than that of prevailing market offerings	1	2	3	4	5
The production cost is less than that of prevailing market offerings.	1	2	3	4	5
Performance of our product is comparable with that of prevailing market offerings	1	2	3	4	5
Features of our product are comparable with those of prevailing market offerings	1	2	3	4	5
Durability of our product is comparable with that of prevailing market offerings	1	2	3	4	5
Conformance to specifications and industry standards of our product is comparable with that of prevailing market offerings	1	2	3	4	5
We have the ability to increase production volume without incurring significant fixed costs	1	2	3	4	5
We have the ability to increase sales volume without incurring significant variable costs	1	2	3	4	5
We have the ability to expand our operations without incurring significant marginal costs	1	2	3	4	5
We have the ability to increase our revenues without incurring substantial marginal costs	1	2	3	4	5
We have the ability to grow without incurring significant human resource costs	1	2	3	4	5
Our customers perceive our product to be equally as appealing as prevailing market offerings	1	2	3	4	5
Our customers perceive our product to have quality comparable to that of prevailing market offerings	1	2	3	4	5
Our customers perceive our product to be as trustworthy as prevailing market offerings	1	2	ю	4	5
Our organization is constrained by lack of: (a) Government supplied infrastructure (e.g., special economic zones, roads) (b) Government support in the regulatory environment (c) Clarity in rules in the regulatory environment	1	0	c	4	Ś
Our organization is constrained by lack of government $R\&D$ investments (e.g., grants, funds for research)	1	2	С	4	5
Our organization is constrained by the difficulty of raising funds from banks	1	2	3	4	5
Our organization is constrained by the difficulty of receiving timely funds from government sanctioned loans	1	2	3	4	5
Our organization is constrained by the difficulty of raising funds from venture capitalists who are risk averse	1	2	3	4	5
Our organization is constrained by the high cost of borrowing capital	1	2	3	4	5
Our organization is constrained by the lack of skilled labour force.	1	2	ю	4	5
Our organization is constrained by the lack of opportunities to collaborate with academic partners such as universities	1	2	3	4	5
Our organization is constrained by the lack of follow through by the government in implementing industry incentives	1	2	3	4	5
				(C	ontinued)

Appendix 2. (Continued)

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Our organization is constrained by the lack of access to experts (e.g., industry experts, medical doctors, academicians)	1	2	3	4	5
Our organization is constrained by the hesitation of our innovators to work with busy customers (e.g., doctors, industry experts)	1	2	3	4	5
Our organization is constrained by less ability to practice expert marketing than prevailing competitors (e.g., MNCs)	1	2	ю	4	5
Our organization is constrained by less ability to attract technical know-how and innovative brainpower than prevailing competitors (e.g., MNCs)	1	7	б	4	5
Our organization is constrained by the inability to detect quickly changes in our customers' product preferences	1	2	3	4	5
Our organization is constrained by the inability to detect quickly fundamental shifts and trends in our industry such as competition, technology, and regulation	1	7	ς	4	5
Our organization is constrained by the inability to resolve customer complaints quickly	1	5	б	4	5
Our organization is constrained by the inability to disseminate quickly competitor intelligence throughout the organization	1	2	б	4	5
Our business objectives are driven primarily by customer satisfaction	1	2	ю	4	5
Expert understanding of customer needs is the most important source of our competitive advantage	1	2	ю	4	5
Our organization takes product-related decisions only after conducting thorough market research	1	7	б	4	5
Our organization takes product-related decisions only after consulting key opinion leaders in the industry	1	7	б	4	5
Our organization systematically measures customer feedback and customer satisfaction	1	7	б	4	5
Our organization has the ability to respond rapidly to competitor actions	1	7	б	4	5
Our organization has the ability to monitor competitors' strengths and weaknesses	1	2	б	4	5
Our organization has the ability for salespeople to share competitor information with top management	1	2	б	4	5
Our organization has the ability to identify and tap opportunities for competitive advantage	1	7	б	4	5
Our organization emphasizes R&D and technological innovations	1	7	б	4	5
Our organization has introduced at least one new product in the past 3 years	1	2	б	4	5
Very often our organization is the first in the industry to launch a new product	1	2	б	4	5
Our organization is typically the first to initiate actions to which competitors then respond	1	7	б	4	5
When faced with a risky economic environment, our organization typically explores it gradually via cautious, slowly increasing behavior	1	7	ω	4	5
In general, our organization has a strong preference for low-risk projects	1	2	Э	4	5
When faced with uncertainty, our organization typically adopts a wait and see approach in order to reduce risks.	1	2	б	4	5

### Appendix 3. Content validity ratio

Formula to calculate content validity ratio (CVR) according to Lawsche (1975):

$$CVR = (n_a - N/2) / (N/2)$$

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Where n<sub>e</sub> is the number of experts who agree on the relevance of the item

N = total members of the panel of expert judges

CVR equals 1 when there is a total agreement among all judges.

In this research, all six judges agreed on the relevance of twelve items. For the remaining three items, five judges agreed while one judge felt slight modification was needed. Hence, the CVR for twelve items is:

CVR for an item where all judges agreed = (6 - 6/2) / (6/2) = 1Thus, CVR for 12 items =  $12 \times 1 = 12$ CVR for an item where one judge did not agree = (5 - 6/2) / (6/2) = 0.66Thus, CVR for 3 items =  $3 \times 0.66 = 1.98$ Therefore, the average CVR for the scale will be (12+1.98)/15 = 0.932

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# **BOOK REVIEW**

**The Trust Revolution** by M. Todd Henderson and Salen Churi (2019) 232pp., €72 (hardback) Cambridge University Press, Cambridge, ISBN 9781108494236

Some books are key because they are able to highlight a new or a neglected topic. They do so through the construction of innovative conceptual schemes, new cognitive heuristics or basic insights derived from a bunch of empirical data. Other books are useful because they rely on rigorous empirical tests, with valid and reliable data which add a limited piece of knowledge to an already consolidated background picture. More rarely, works manage to combine the two aspects: new insights which bring the attention of the scientific community to new problems, and empirical analysis which then puts these ideas to the test of illustrative empirical material. Henderson and Churi's book definitely belongs to the third category. The book has a specific focus on American society, but its findings are surely applicable elsewhere.

The topic on which the two authors focus their attention is trust, a fragile concept and a solid reality, as often defined by sociologists. Trust is a key ingredient in the texture of society. The novelty that the book presents is both simple and dazzling: we have become accustomed to thinking that trust has drastically decreased in the last few decades and, in particular, that the sudden decline in institutional trust has not been offset by an increase in interpersonal trust. These are the two analytical dimensions on which the social sciences have focused their attention in their empirical investigations: we trust either others or institutions. *Tertium non datur*. Even when viewed through the lens of social capital, the response looks essentially the same: the last decades have been characterized by the inexorable decline of the networks of trust, the erosion of sociality, withdrawal into primary networks and an inability to act for the collective good, putting at risk the functioning of market mechanisms and the foundations of liberal-democratic systems.

The exclusive attention to these two dimensions (institutional and interpersonal) has neglected the growth of trust in middle-tier socio-technical systems (from Uber to eBay), which have literally altered the landscape of our societies. The first chapter of this book documents the apparent collapse of trust in American society. Many surveys and quantitative data (on which many sociologists and political scientists have built their careers) seem to show that trust has been constantly and drastically diminished:

We should be clear – we are not claiming that the United States of yesteryear was a paradise of trust and confidence and good will toward all. Our history is full of violence, political turmoil, and plenty of ill feeling toward our fellow man. But, the erosion in public trust of institutions, from a baseline of the post-World War II era, is plain in the data. (p.17)

In the second chapter, it seems that this requiem for trust is premature, so much so that it can be argued that we have never had as much trust as we have today. The point is that we must look in the right direction: not to institutions and government, not to direct interpersonal relationships, but to the complex of socio-technical systems to which we turn every day for the purchase of goods and services of all kinds, from the basic to the voluptuous. Surveys and media attention do not record growth in trust simply because they look in the wrong place:

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Instead of asking whether people trust the police or the *New York Times*, we should be asking how it is that eBay processes 10,000 transactions per second between strangers all over the world without a government anywhere in sight. (p.6)

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The third chapter traces a classic theme in the literature on trust: trust is indispensable in cooperation, exchanges and contracts. Without it, the transaction, monitoring and control costs would be very high. This, in large part, explains the development (or non-development) of countries and economic systems. However, the demand for the trust needed for economic development cannot constitute a satisfactory explanation for its supply. Just as the need for efficiency does not explain the birth of efficient transactions, the supply of trust has its roots in the relational and institutional context that support it. The supply mechanisms are at the centre of the next chapter, which traces a *fresco* in large strokes of human history through four periods, differently characterized by the supply of trust: the hunter-gatherer societies, the agricultural revolution, the industrial period and the age of information. When supply and demand for trust meet, a market for trust can be generated within which the government acts as both provider and as regulator.

Subsequent chapters substantiate the trust argument with two illustrative cases: the New York stock exchange and taxicabs. New York stockbrokers were privately regulated, until the late 1700s, when the New York Stock Exchange came into existence to provide trust. Trust in taxicab and other ride-sharing services is linked to the development of the internet, the smartphone and several reputation technologies. The book's argument is expanded to the Uber case and a sketch of the government regulation required to improve the efficiency of these markets.

All in all, the book offers a compelling account of a key topic so far neglected by the literature on trust; it addresses this topic in a very clear way and it provides new knowledge for a broad audience. The specific focus on the American case narrows the perspective, although the level of abstraction of the argument helps to include a broader view. I would also like to point to a difference which is somehow overlooked in the book: trust and quality are closely connected in the working of the market for trust and this is particularly so in markets where the attributes of products are difficult to unravel from a consumer's point of view. Quality standards give information about the attributes of a product and these attributes can be classified, depending on the ease with which they can be measured. Search attributes are those that can be verified at the time of the transaction. Experience attributes can be assessed only after the transaction has taken place. Credence attributes cannot be objectively verified. In the first and simplest case, the availability of information and prices about goods/services is the main driver of markets for trust. Agents have a common interest in exchanging and what they need is mainly information about commodities whose quality is easy to test (search goods). In the second case, these markets are based on reputation. The interest of agents may diverge (e.g., opportunism and malfeasance) and quality can be assessed only after the transaction (experience goods) within an effective rating system. Thirdly, these markets may require social identification and a mutual recognition among agents as member of the same group (e.g., collective identity). Transaction occurs between agents that share the same meaning and value-system (credence goods). In this case, I would maintain, the problem of trust overlaps with the problem of identity and meaning-making mechanisms and the idea of market for trust could be deceptive.

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# **BOOK REVIEW**

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**Cyber Republic** by George Zarkadakis (2020), 216pp., \$US27 (hardcover) MIT Press, Cambridge MA, ISBN 978-0-26-204431-8

Thanks to rising levels of inequality and increasing acceptance of illiberal and populist political ideologies, democracy is facing a crisis of legitimacy. It is essential that we find a way to preserve liberal democracy while simultaneously improving the lives of ordinary citizens. This is the challenging task that George Zarkadakis tackles in *Cyber Republic*. By leveraging blockchain technology and the Athenian idea of direct democracy, Zarkadakis reckons we can reclaim our digital future and preserve liberal democracy.

What are the links between democracy and liberalism? While it might be natural to assume that democracy and liberalism go together like a horse and carriage, this is simply not the case. Democracy, as Zarkadakis conceives it, is a mechanism by which decisions are made. Specifically, a decision is democratic if it is based on collective deliberation about common ends decided by majority vote. Proposals that get the greatest number of votes are the ones that guide our actions, and each participant in a democracy has an equal right to vote. Conversely, liberalism is a moral and political project, concerned primarily with the dissemination of equal rights, regardless of family origin. And herein lies the issue: it is possible for an illiberal majority to vote against liberal values. For example, if the majority of voters in a country comes to believe that same-sex relations should be punishable by death, then we need a mechanism for protecting the rights of the minority groups concerned. This is how liberal values can be undemocratic (without being antidemocratic), as such groups can be argued to deserve protection, regardless of what the majority believes. Thus, it is easy to see the (conceptual) possibility of an illiberal democracy and undemocratic liberalism. Undemocratic liberalism safeguards the rights of minority groups against the wishes of a majority, while illiberal democracy priorities citizens' rights, even if these rights infringe the basic rights of others (for example, deciding not to let immigrants enter their country).

Liberal democracy, therefore, 'is a system of government that adopts a representative form of democracy in order to defend citizen and human rights against the tyranny of the majority' (p.3). Thus, liberal democracies are essentially a way to keep citizens at arm's length from having a direct say in the running of government, acting as a system of checks and balances to protect the rights of minority groups. Undemocratic liberalism is considered to be morally superior to illiberal democracy, and for many years the undemocratic nature of our liberal democracies has not really been under strain. This, however, is changing. Democracy and liberalism can come apart, and indeed they have.

The rise of authoritarian leaders in ostensibly democratic states (such as Trump in America, Orbán in Hungary and Putin in Russia) provides evidence that illiberal democracies are not only a conceptual possibility, but also a political reality (p.1). Citizens increasingly feel that liberal elites have taken the major share of the profits from globalization, and so we are witnessing heightened levels of nationalism, fuelled by strongly illiberal and authoritarian sentiments (p.4). These responses are, in part, exacerbated by the fact that people have lost faith that their governments really are democratic. A recent study found that 64% of citizens living in liberal democracies think their government does not act in their interest, over 50% are disillusioned with their political system and 54% think they (citizens) have no impact on political decisions (p.5).

All these factors create the perfect political storm. Increasing levels of wealth inequality have led many citizens to feel that their governments have failed them. This has been fertile ground from which internally focused nationalists have risen to power in many former liberal democracies.
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Populist leaders frequently promise to improve the lives of ordinary citizens, and this is often at the expense of marginalized groups. Politicians running on populist or authoritarian tickets often explicitly seek to undermine liberal values that are key to protecting the most vulnerable members of society. As noted above, one of the key drivers of this nationalistic trend has been the failure of systems for the equitable distribution of resources, leading to the hoarding and accumulation of wealth by a select few. Zarkadakis believes that artificial intelligence (AI) can provide the economic and technological stimulus required for a more equitable society. Putting to one side questions of whether AI will become sentient or have general intelligence, he focuses on the disruptive effects such systems may have on employment. Specifically, in a world facing increasing levels of automation, can liberal democracies survive in the absence of traditional types of employment?

While there are many competing definitions of AI, Zarkadakis takes a pragmatic approach, essentially defining AI by its goal, which is 'to make computers solve problems we generally associate with human cognition and perception' (p.13). Thus, the development of more sophisticated AI would seem to go hand-in-hand with increasing levels of automation, leading to greater levels of unemployment. Predicting the compensation effects of technology is, however, rather difficult. New technologies are often introduced as a means of solving existing efficiency problems, and so it is usually easy to track who will be displaced by the technology (horse carriage drivers were the most vulnerable when the car was first introduced, for example). However, predicting how these technologies will create markets for new work (compensation effects) involves many variables, and this is often reflected in there being far more talk about jobs lost as opposed to jobs gained (p.32).

What we can be sure of (given that it is already occurring) is that AI will have a massive impact on our economy. For example, PwC predicts that AI will have added US\$15.7 trillion to global GDP by 2030 and Accenture estimates that AI will double economic growth by 2035 (p.12). The worry, then, is that such increases in economic prosperity will follow the current *status quo* and continue to be accumulated by a select few. Zarkadakis argues that AI might be able to alleviate some of these economic imbalances by optimizing resource distribution and improving decision making (p.39). While acknowledging the deleterious effects that many AI applications have had (e.g., predictive policing, political polarization, increased gender and racial inequality), Zarkadakis nonetheless believes that AI presents a huge reservoir of untapped potential.

We are introduced to the exact nature of the future cyber republic, and the steps we ought to be taking now to ensure that we get there. Running through familiar arguments concerning surveillance capitalism and digital authoritarianism, Zarkadakis correctly identifies the breaking up of digital oligopolies and the preservation of data privacy as key issues (p.57). This cyber republic is based on three core principles:

- 1. rethinking business models for an AI economy
- 2. repositioning AI as a human-centric technology
- 3. extending citizen rights (p.62)

Chapter 6 offers us a more nuanced account of what exactly might be involved in implementing (3). Specifically, Zarkadakis argues that we can leverage AI to organize citizen assemblies, leading to a form of deliberative democracy which would not have the same shortcomings as traditional liberal democracies that try to keep citizens at arm's length from the process of actual governance. Citizen assemblies, such as the meeting of minds initiative in Europe (discussed at length in the book), involve putting together a representative sample of ordinary citizens to discuss a key policy issue. In the meeting of minds project, citizens learnt about and then discussed various issues involved in brain science research. In such discussions, the knowledge gap between experts and lay-persons is reduced, and through this process citizens come to realize their civic duties. Experts guide the discussion and introduce major themes, but the onus is on the assembled citizens to run the meetings.

In such an assembly, as Zarkadakis notes, citizens shift from being concerned with their individual interests to being concerned with the common good (p.72). Citizens encounter a plurality of perspectives and are thus prompted to think beyond their own self-interest to consider the opinions of others. Thus, a degree of reasonableness is achieved with citizens engaging in a charitable interpretation of the views of others and using this to guide discussions in the pursuit of policy. The hope, therefore, is that opinions that may be highly polarized (climate change denial, belief that the earth is flat, that children should not be inoculated) can be ameliorated with the use of citizen assemblies, as these assemblies seem to encourage the shifts in perspective needed to combat such binary thinking (p.83). However, an important drawback of these assemblies is that they are often prohibitively expensive and difficult to scale. AI, Zarkadakis argues, can perhaps solve this problem.

Zarkadakis urges us to reconsider our framing of AI. Specifically, he argues that, instead of understanding AI as a kind of 'other' in tasks, we view our interaction with AI systems as involving multiple feedback loops. This way of perceiving artificial systems draws on work done in cybernetics from the 1950s and 1960s and attempts to understand 'how self-organization occurs in complex systems, but also how emergent systemic behaviours affect the parts that make up those systems' (p.87). Such complex systems have emergent behaviour that can only be fully appreciated when considering the iterative nature of the feedback loops affecting the various components of the system. Zarkadakis believes that this provides a helpful way of understanding our relationship to AI. As a socially embedded technology, AI is not 'out there', but rather is part and parcel of many of our interactions with the world. We are constantly involved in various feedback loops when we interact with AI-based systems, leading to a kind of coupling between us and our machines (p.89). In this situation, humans are not just an input. Rather, humans influence the kinds of AI we produce, and AI influences the kind of humans we become.

Combining this cybernetic approach to AI and his advocacy of deliberative democracy, Zarkadakis provides a framework for embedding cybernetic conversational agents in citizen assemblies (p.94). These conversational agents would go some way to resolving the two issues mentioned earlier: cost and scalability. In terms of cost, these systems could enable facilitation, translation, recording and reporting, all of which would previously have been performed by human agents (p.94). Additionally, automating large parts of the process would also allow these assemblies to scale. Important to note, however, is that these agents are not automatic in the traditional sense, but rather serve as mediators in human–machine systems. Thus, they enable, not merely automate, democratic deliberation. To perform this task, though, they must be capable of performing seven key tasks:

- 1. understand the context of the debate
- 2. facilitate knowledge discovery and acquisition
- 3. assess knowledge
- 4. translate
- 5. perform empathic monitoring of constitutional checks
- 6. timekeeping.

If the system can perform these tasks, it would enable liberal democracies to be more inclusive and allow more interactions between citizens and the laws and policies that impact their lives. In understanding liberal democracy as a cybernetic system, this proposal stresses the importance of evolution. As cybernetic systems are in a constant state of flux (because of feedback loops between inputs and outputs), they must either evolve or stagnate. The question, therefore, becomes how to guide the evolution of liberal democracy in a desirable direction. Moreover, how to do this in a way that leverages this understanding of human–machine collaboration, and guards against the further dominance of centralized digital oligopolies.

Zarkadakis shows that a decentralized future is indeed possible through the appropriate use of blockchain technology (p.100). His central claim defended is that the current oligarchic structure

of digital platforms ensures that the value of these platforms belongs to their owners, and not their users. This is an issue as the value of these platforms is a product of user data.

if no one wanted to post content on Facebook, or use Google to search the web, those companies would also disappear. It is the 'liquidity' of a digital platform, measured by the volume and frequency of user interactions and transactions, that makes a platform valuable (p.108).

The benefits of blockchain technology, and cryptonetworks specifically, are that through their distribution of tokens to network participants, they allow a more equitable distribution than the current system of the value generated by network effects. In the current system, as more participants join a network, the value of the platform increases, but all of this value is held by the owners. However, in the new web 3.0 scenario, as network value increases so does token value. As these tokens are owned by network participants (users), wealth is redistributed throughout the network instead of being hoarded at the top.

Chapter 9 brings the theme of decentralization to bear on questions of governance and regulation of digital platforms and data privacy. Zarkadakis argues that digital platforms in their current iteration still exhibit centralized decision-making processes and goal setting. The digital economy has not done much to disrupt standard methods of corporate governance (p.119). In a decentralized scenario, network participants have far more power to shape the structural aspects of their platforms. If users are not happy with the way a platform is being run, they can take their business elsewhere. In a centralized model, users are not empowered to make these kinds of switches because they are locked into various platforms (such as Amazon) and the decisions made by the owners. In a decentralized system, users can vote with their feet, using their tokens to influence platform design and governance (p.121).

Issues of data-sovereignty have been the subject of extensive debate recently, and Zarkadakis believes that data property rights will be essential for solving existing wealth inequalities (p.127). His proposal is the creation of data trusts, which would be mutual organizations with fiduciary responsibilities that act as stewards of citizen data (p.128). Citizens would be able to sign up for these trusts and have their data pooled. This pooled information could then be made available to businesses and governments, the data trusts negotiating with interested parties on behalf of citizens. Significantly, however, the value generated from these interactions would be distributed to the rightful owners of the data – citizens.

In his final chapter, Zarkadakis focuses on the role that government plays in the management of the commons. Specifically, he uses this as an example to help clarify the story he has been telling thus far and offers a glimpse of what a true cyber republic might look like. He gives examples of value alignment problems from failed smart city projects. A fully integrated smart city may seem ideal in the imagination (think of fast Wi-Fi, driverless cars on demand, etc.): in practice, when these initiatives are run by private companies, they become cities of surveillance. The value of digital privacy is habitually overlooked (or understood in an overly individualistic way), which often results in (justifiable) public outcry. Zarkadakis claims that a decentralized, cryptographically enhanced mechanism could build in appropriate values. By decentralizing decision-making and wealth creation, citizens are given the economic and political power to ensure desirable social outcomes.

In closing, I will present one general criticism of the way Zarkadakis understands technology, and then one directed at his representation of AI. The first has to do with the 'techno-solutionism' found throughout the book. It is often natural, during times of crisis, to look towards technology for a solution. This is not a problem in itself. The problem arises when technological interventions are pursued at the expense of other, perhaps more effective, interventions. This can come about when we ask the wrong questions about technology: instead of asking whether we need a technological intervention in the first place, we look for technological solutions right from the beginning. This frames our ability to solve problems rather narrowly as

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it assumes that there should be technological interventions before considering whether our issues are not of the kind amenable to technological intervention.

While there are many examples of this in the book, there is one case in which Zarkadakis is very clear on this issue: 'given the huge benefits of AI, we must find a way to embed this revolutionary technology in our system of government without jeopardizing liberal values' (p.42). Here we have a clear statement that we must employ this technological intervention. While Zarkadakis does acknowledge the negative side effects of AI-powered systems in politics (such as polarization), by framing the debate as one that requires us to embed AI in our systems of government, he risks ignoring non-technological interventions that may do just as good a job but have more predictable effects. Of course, and especially in the case of citizen assemblies, we have a non-technological intervention combined with an appropriate technology to make deliberative democracy more practical. I have nothing against this argument in particular, but have reservations about the general strategy which underpins our framing of these interventions as necessary.

My second, more specific, critical remark concerns the framing of AI systems. Zarkadakis claims that 'when it comes to AI systems, the human programmer becomes irrelevant beyond the initial training of the algorithm, and the system evolves its own behavior and inner complexity as it crunches more data' (p.86). While Zarkadakis suggests that AI 'can make complex decisions autonomously by accessing vast amounts of diverse knowledge and data' (p.40), we need to keep in mind that allowing an AI to make such an 'autonomous' decision is itself a decision that we make. How we evaluate outputs of AI systems is something that is up for negotiation, and so while these systems may be autonomous in some functional sense, they are not self-governing and can therefore be designed not to make decisions on their own. The idea of programmers becoming irrelevant is a dangerous one, possibly an abdication of responsibility. We need to make programmers aware of the potential implications of their systems so that they see just how relevant they are.

*Cyber Republic* is a bold attempt to ameliorate the current crisis of liberal democratic legitimacy by leveraging blockchain technology in a cybernetic framework. The book is an ambitious one and sweeps through many fields of study. It does a good job of setting the scene, illustrating the advantages that may come from our careful use of decentralized systems. One of its most important contributions, to my mind, comes from the clear light it shines on the potential sources of failure of liberal democracy. While I am still pessimistic about whether technology is the answer to this crisis of legitimacy, Zarkadakis is astute in his diagnosis, and provocative with his remedy. Whether you think technology is the solution or the problem (or both), this book provides something for those on either side to ponder.

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## **BOOK REVIEW**

**Power and Technology: A Philosophical and Ethical Analysis** by Faridun Sattarov (2019) 198pp., \$US120 (hardback) Rowman & Littlefield, London, ISBN 978-1-78661-130-7

Concepts can be powerful things, and few concepts are more contested than power. In his recent book, *Power and Technology*, Sattarov (2019) sets out to detail various notions of power while simultaneously showing how power and technology are related: 'phenomena of technology and power are becoming ever more inseparable' (p.1). He laments how others speak of power without ever saying what they mean by the term.

Sattarov's approach is to argue that power can, and perhaps must, be understood through four distinct varieties of the concept: episodic, dispositional, systemic and constitutive. Rather than seeing these varieties as conflicting, he attempts to combine them in one pluralistic master concept, where each variety allows us to see a different facet of power. While doing so, Sattarov ends up with a book that at times seems to explain just about everything as some sort of power, which might, as we'll see later on, be taking the notion of a master concept a bit too far.

While the book deals admirably with various historical concepts of power from social theory and science, technology and society (STS) studies, Sattarov also aims to combine approaches to power from a broad range of other disciplines, such as political theory, social psychology, international relations, history, economics, psychology and philosophy. The major benefit of reading a book from another disciplinary camp – I am a political theorist – is the enjoyment of exploring seeing through new perspectives. All the same, I could not help but wonder where the political theorists – apart from the unavoidables, such as Hobbes and Locke – were hiding in this discourse on power. After all, or so I thought, few disciplines have been as concerned with power as politics. Nevertheless, the choice of theories, and theorists, serves the book's purpose well.

As Sattarov constantly reminds the reader, his book is not meant to be the complete story, but something a proposal of a new theory of power which serves as the starting point for further analysis. It is 'the first word; it is by no means the last' (p.26). It is also, at times, clearly placed in the tradition of critical theory. Concepts, Sattarov states, change the world they purport to describe. Concepts themselves have power, and the power of philosophizing is thus an exercise of power. That Sattarov is wary of power is clear throughout, as he focuses on those exposed to power, the vulnerable, and pleads with us to end our quarrelling over the concept of power and adopt his pluralistic concept 'at least for the sake of the powerless, the vulnerable, the poor, and the marginalised' (p.171). With this in mind, I will first present my take-away from reading this book. This will take me through a (necessarily too brief) summary of the main ideas and structure of the book. I will then turn to the points that I believe are either missing or would have strengthened the argument proposed.

The first part of the book revolves around the development of a pluralistic concept of power. Each of the four types of power is presented in individual chapters: episodic power (2), dispositional power (3), systemic power (4) and constitutive power (5). The beginning of the book was the highlight for me. Here Sattarov provides an interesting and insightful literature review focused on the various concepts of power used by a variety of authors from the disciplines mentioned above. The book starts strong with an agenda to show how a pluralistic concept of power is both possible and necessary. This seems plausible enough, even for a political theorist fond of keeping various concepts distinct from each other. Such a pluralistic concept, he argues, is necessary because we need an 'approach to power that can coherently reconcile these different views in a unified framework, while doing justice to different conceptions of power' (p.6). In doing so, he pays homage to Amy Allen (1999), Mark Haugaard (2010), Stewart Clegg (1989) and Sheldon Wolin (2004).

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The first kind of power is episodic power. This is the kind of power someone uses to influence someone else in a particular situation. Power is here seen as a social relation, in which asymmetrical power allows an actor to make something happen. Sattarov focuses on the following types: coercion, seduction, manipulation, persuasion, force and authority. An interesting aspect of episodic power is that it accounts not just for outright coercion and obvious force, but also the kind of influence that lets an actor change what someone else wants. Nudging is here used as an example of manipulation, but Sattarov does not go particularly deep into each of the various types. As persuasion is portrayed as a form of power, it should be clear that the concept developed will see power in all human relations. Distinguishing various forms of non-physical influence is also part on the ongoing discussion of nudges powered by new technology, as seen in, for example, Sætra (2019b) and Mills (2020). The discussion of persuasion also shows how some work remains before Sattarov's typology is finished. Authority is listed as a form of episodic power, as is persuasion – which is then said also to contain authority as a principle of persuasion (p.40). While not ruinous for the argument made in the book, such details show that there is room for further improvement in the new master concept of power.

After a thorough philosophical discussion of episodic power, Sattarov briefly gives some examples of how technology might be related to all types of episodic power – without, however, going into sufficient detail for the role of technology to become clear. This is one of the shortcomings of the book; similar points can be made for most chapters. The following example both begins and ends the discussion:

Another example of online seduction is when social networking websites and domain, such as Facebook and Gmail, offer their users 'free' services, where such 'free' services are in fact based on users giving up their personal information which can then be used by these internet firms for the future purpose of targeted advertising. (p.37)

While the mechanisms involved, and an examination of who gains and suffers from episodic power in such cases, may seem superfluous for Sattarov, it still makes the technology part of the book seem both shallow and at times a bit dated. Many authors have written about superficial voluntariness and the true nature of 'free' services. References are the minimum requirement when the examination of technology is as brief as it is in the book.

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Dispositional power is the second type, and it is something akin to latent power – power someone simply has, regardless of whether it is used. I may, for example, have the ability, capacity or potential to destroy something or someone. On a slightly less gloomy note, I may have the potential to build and construct things – or to reason, experience, develop and travel. An interesting example used is that of the poor who may have the ability to eat caviar, but still lack the ableness to do so (caviar is, after all, expensive) (p.46). Another example is the use of the word 'can', which might point to what I am able to do (I can read – if enabling conditions are present, such as glasses and something to read) and it can point to what I am actually able to do right now (I can read, because I have been provided with glasses and a book). At this point it becomes somewhat excruciating to see the discussion simply moving on without even a hint of a nod to the concept of liberty, and particularly Isaiah Berlin's distinction between negative and positive liberty. These two concepts are, after all, in a caricatured sense a discussion about whether it is preventing or enabling conditions that matter when power and freedom are examined (Berlin, 2002). I will return to this point later on.

The discussion of technology at the end of the chapter is once again quite brief, but it touches upon the question of whether people have power through technology or if technology itself possesses power. Sattarov concludes that new technologies have changed 'the nature of human action of power', and while he could have referred to the ongoing discussion of, for example, gaps between real and detectable/attributable responsibility and the early work of Matthias (2004), or later work by Gunkel (2017) or Nyholm (2018), he does not. One reason might be that what others discuss as the relationship between *agency* and technology, Sattarov prefers to see as issues of

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power (p.52). Not even when Sattarov devotes a large part of chapter 7 to the relationships between power and responsibility does this topic really get sufficient attention.

The third form of power is systemic power. This entails a departure from individuals as focus is shifted to structural and systemic conditions that constitute the distribution of power – and powerlessness. In terms of the ableness just discussed, systemic power is really about the distribution of ableness – how some people come to be able to exercise their natural abilities while others may be prevented from doing just this. Systemic power is not a competitor to the concepts of episodic and dispositional power, but rather a way to examine how these forms of power are distributed and can be exercised. Sattarov focuses on four types of relations in which systemic power manifests itself: namely, social, economic, cultural and political. In the discussion of how technology relates to this, there are few clear examples provided, and some – in relation to ideological power, for example – show that systemic power is at times closely related to episodic power and persuasion (p.64). The power to shape minds is connected to Nye's (2011) term 'soft power', and this again could easily be related to how algorithms are used to shape our perception of the world (Sætra, 2019a). Sattarov, however, chooses to discuss this form of power in terms of technology in general, particularly in various forms of historical media.

Finally, the last form of power is constitutive power – the power that constructs, shapes and constitutes our very selves. Foucault is mentioned as a key philosopher of constitutive power, conceiving power as 'ubiquitous, dispersed, and systemic' (p.7). However, as Sattarov notes, Foucault does not ignore the individual as a consequence, which makes Foucault an author who provides examples for several of Sattarov's four types of power. Sattarov states that constitutive power focuses 'on the transindividual ways in which individuals are themselves constituted by relations of power'. This could also be related to the work of Julie Cohen (2012), who argues that privacy is required in order to provide the space in which what she labels the 'postliberal' self develops. Cohen, however, discusses this in terms of liberty, while Sattarov calls it power. This could also have been related to the shaping power of algorithms and how algorithmic prediction may shape individuals through such mechanisms as the expectancy effect, Thomas theorem and Proteus effect (Sætra, 2019a). The technological examples provided relate partly to Foucault and his emphasis on surveillance and disciplinary power. This would have been a natural opportunity to use examples of new technologies and issues of privacy, both in relation to how surveillance is a form of interference and the nature of privacy as a relational and public good (Sætra, 2019b, 2020), and how privacy is seen as a form of power (Véliz, 2020). If so, it could have been established that modern surveillance is something new, made possible by modern technology. Instead, he paints a picture that does not really describe the nature of modern threats, and at times simply asserts that constitutive power is now ubiquitous, whereas it was not in the past. Reading these parts, it is tempting to ask whether life in small and tight-knit societies (in which the church had great power) was really that much better than life in modern society. Instead, the main point of the chapter seems to be that values inevitably enter into the design and application of technology; it is not made sufficiently clear how.

Sattarov argues that the four types of power are complementary rather than mutually exclusive ways to understand power. He suggests that we consider them all legitimate statements of what power is, and that when combined they form a pluralistic framework for understanding power. In various situations, he argues, 'the theorist of power either zooms in or zooms out', depending on current needs and purposes (p.7). The different levels correspond to different 'levels of analysis that require different levels of abstraction' (p.6). The compound concept of power developed is a pragmatic one. Sattarov does not set out to refute any concept of power. Instead, he attempts to bring what is useful from different concepts (and he generously seems to find something useful in them all) together in a rather broad framework that provides the tools for understanding any form of power. One problem with this approach is that it will, by definition, provide the tools to understand any form of power, because it ends up arguing something along the line that everything is – or can be – power. The four types together describe direct and indirect power, individual, relational, and systemic power, physical and non-physical power, and also intentional and unintended exertions of

power (pp.37, 48). This might cause some problems, but the upside, of course, is that a pragmatic concept of power should be readily usable for a wide variety of situations and forms of analysis.

Unfortunately, Sattarov does not convincingly establish how the pluralistic framework could in fact be used, and does not propose a system for employing it and for deciding which of the concepts are most applicable in different situations. Or, perhaps preferably, how a pluralistic concept should entail approaching each situation from a variety of perspectives. This, I thought, may simply be premature misgivings based on the fact that I had not yet arrived at part 2 of the book. This consists of chapters on algorithms (6), a linking of power with a range of other concepts (7), 'practical implications' (which turns out to be a Europe-centric examination of responsible research and innovation) (8) and finally a chapter on political economy (purportedly ethics-free as the chapter is entitled 'Power in the absence of ethics: political economy') (9). Based on the description of the chapters, there seemed to be some hope that we would now see the pluralistic concept of power in all its glory, applied to a range of settings and proven to be useful. Alas, this was not to be.

Some effort is made to refer to recent analyses of what is referred to as algorithmic power. After some introductory comments on algorithms, brief discussions of algorithms and each of the four types of power follow. The discussions are too brief to do the subjects justice, and this shortcoming is exacerbated by Sattarov's failure to guide the reader to the literature available on, for example, manipulative and persuasive technology, which he discusses under episodic power. The closing discussion of algorithmic bias is a bit longer, and provides a decent introduction to the main dangers of bias, but without referring to central recent work on the topic.

In chapter 6, Sattarov relates power to the concepts of responsibility, vulnerability, authenticity and trust. While interesting, this chapter fails to connect to other work on technology and each of these concepts. In addition, we have now come to a part in the book where references to the four types of power become rather sporadic. Rather than showing how the theory developed in part 1 might be applied. Sattarov introduces the reader to what feel like new and only tangentially related topics. The European framework of responsible research and innovation is put in the spotlight, though Sattarov never makes clear why it belongs in the book anyway. The introduction of the topic at this point in the book feels somewhat arbitrary. Once again, the four types of power are not really guiding the analysis. Finally, chapter 9 presents political economy as the realm of no ethics and gives the example of how forces in Iran resisted the introduction of mobile broadband. It is unfortunate that the pluralistic theory of power is not given a chance to prove itself, and that the last part of the book runs the danger of frustrating the reader who wants to see the theory applied, particularly in better developed examples of technology.

I was left waiting for a discussion of what power is not so that we might usefully discuss some things as power, and other things as something else. A nagging concern throughout the first part of the book has been just this. How can we argue that just about everything is power without diluting the concept to such a degree that it becomes useless, and in practice encompasses all other concepts that have historically proved to be quite useful in

Everything is what it is: liberty is liberty, not equality or fairness or justice or culture, or human happiness or a quiet conscience. (Berlin, 1969)

That, in a nutshell, is the book. I hope the following will be taken as friendly banter, because it is quite simply the result of frustration stemming from the failure of a book on subjects as fascinating as power and technology to focus on its subjects. I'll attempt to introduce these points briefly here, well aware that others may have radically different opinions on whether these things are actually shortcomings in Sattarov's book, or the unrelated ramblings of someone belonging to the wrong academic tradition. I take some solace in the fact that Sattarov explicitly states that his goal is a work of analytical philosophy, in which conceptual analysis is central, and also that he wants to include my discipline of political philosophy in the inner circle of disciplines invited jointly to create a pluralistic concept of power.

A striking omission in the book is its neglect of a concept closely related to power – freedom, or liberty. The very notion of liberty is intimately linked with both the idea of having power, and of being free from the power of others. Liberty could, in fact, be argued to be a mirror concept of power. Berlin (2002) discusses positive and negative liberty, which is intimately connected to the idea of ableness, and what sort of power is seen as problematic. Carter (1999) also considers liberty in general; his discussion of coercive threats, and when these are problematic, would have provided the book with a bit more nuance. Raz (1986) discusses the same subject, and distinguishes between manipulation and coercion, ending up with a theory of liberty as autonomy which is quite close to some of the ideas of power presented. Pettit (1997) and List and Valentini (2016) presents theories of liberty that describe what sort of power is inimical to liberty – not only when exerted, but when it can be exerted. This list of some classics in the philosophy of liberty is, of course, not extensive enough to make sense in itself, but I invite Sattarov and his readers to examine whether there is something useful to be added to the theory of power from the side of the fence that is concerned with freedom from the power of others.

To me, Sattarov's proposal for a new concept of power distorts the useful distribution of labour between, for example, power and liberty, and thus impoverishes the explanatory power of both concepts. Power is, for example, said to be both the power to influence and the power to be influenced. Power is power, but it is also the lack of it – vulnerability. Power is intentional and unintentional use and capacity for both physical and psychological force. It is even in our very structures, and disconnected from individuals, and it constitutes both ourselves and, in turn, those structures.

Isaiah Berlin is not mentioned in the book, but he serves us well as a proponent of a different approach to philosophical analysis than the one proposed by Sattarov. For Berlin, a concept is useful if it is clearly demarcated, and if it does not attempt to subsume other concepts within itself. Berlin (1969, p.172) famously emphasized, after Bishop Butler, that 'everything is what it is' and not something else. Liberty is liberty, and not power, justice equity, or fairness. Berlin is also famous for his pluralism, but that is a very different kind of pluralism, one of values, not the combination of different concepts into larger frameworks.

I pick up Berlin's challenge and argue that power is what it is, and not liberty, justice, equity, fairness, responsibility, trust, etc. This conflation of concepts is quite evident in the discussion of algorithms in which what Sattarov presents as unfair use of power is never really connected analytically to issues such as fairness, justice or liberty. It thus ends up becoming a story of how power is everything, and since power can be used for bad things, the arguments further erode into a general critique of power. Power can also be generative and positive, and this is given too little attention in Sattarov's book. A discussion of how other concepts, such as liberty and justice, might provide ways to evaluate the use of power, might have helped.

While I perceive that Sattarov aims to create something akin a 'complete theory of power', he actually states that such a theory 'would be as unthinkable and unconvincing as a complete theory of holes'. He argues that such complete theories may obscure important facets of power, and that gaps are thus created, gaps that 'grant power invisibility thereby affecting chances of resistance, liberation, and counter-power' (p.25). I agree, and I would also add that by creating a complete concept of power that effectively subsumes most other concepts of social and political theory, any proper debate and understanding about anything other than use and abuse of power, and being the recipient of this, is made more difficult.

As should have become clear, this was a highly stimulating book to read. The difficulty is that this stimulation generated so many thoughts and so many ideas that could have been addressed in the book. This may lead to the impression that the book is flawed, but that is not the main or only impression I want the reader to retain after reading this review. I want to emphasize that the book is very solid in its analysis of power, especially from a social or critical theory vantage point, and that it deals comprehensively and fairly with many different concepts of power. It is also interesting to see an attempt to combine all these different types into a pluralistic theory of power. I suppose this is where my frustration sets in.

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As I was intrigued by the idea of power as a pluralistic concept, I was saddened to see that the pluralistic concept developed in part 1 of the book was largely neglected in part 2. This was where earlier issues were to shine, and where it would be shown that the pluralistic concept made sense. Instead, the pluralistic framework itself was largely ignored, and even the four various forms of power only mentioned in passing – a nod to episodic power here, to systemic power there – without any effort to show how multiple forms of power improve the analysis of a given example, or that all the various forms previously established are required. Ironically, Sattarov turns himself into one of the very figures from which he proposes to save us, those who say 'power' without providing a rigorous and comprehensive definition of the concept. Sattarov *says* he does, and while he certainly defines the four forms in separate chapters, he forgets to provide a comprehensive account of what the combined new concept actually is and means in practice.

The result is a book that starts with vigour, but ends on an anti-climax. I would like to have seen more discussion of how power relates to such concepts as liberty and justice. Let different things be as they may; power is not everything, and making sense of the world would perhaps be easier if power was not partially conflated with justice, fairness, poverty, vulnerability and liberty. I would also like to have seen a stronger emphasis on how Sattarov regards methodological individualism. Individuals – people in general – often seem to be eliminated from the discussion of power. I would then like to have seen more about the good potential of power, and I believe this could easily have been shown if the aforementioned concepts of justice and liberty had been introduced, even briefly. The final omission – and it is a major omission from the book – is the attention given to details of technology, and modern technology in particular. While his account of power is comprehensive and at times impressive, Satarov's account of technology leaves me wondering if the book should have been called just *Power*.

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# **BOOK REVIEW**

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**Artificial Intelligence as a Disruptive Technology: Economic Transformation and Government Regulation** by Rosario Girasa (2020) 331pp., €68 (paperback) Palgrave Macmillan, London, ISBN 978-3-030-35975-1

I am pleased to write a review of this book. It brings together multiple aspects of how artificial intelligence is influencing governments, industries (both public and private) and societies. Such concepts as super intelligence are cutting deeply into our personal lives. The author brings decades of academic and professional experience from the legal profession, and his work reflects this perspective. The book is overall easy to read and the layperson as much as the professional will benefit from its knowledge.

Girasa is not attempting to solve problems; he is not even suggesting solutions. Rather, he is bringing to the reader's attention growing concerns about artificial intelligence (AI) and how corporations are leveraging AI to their advantage while governments (mainly in the US and EU) try to keep up with new legislation to protect the rights of private citizens. Conversely, governments are also using AI to collect more information about their citizens, infringing the privacy that people in the US and the EU still take for granted.

Your reviewer is a university professor in management information systems. Over the past five years, I have developed a keen interest in how AI-related technologies have been eroding our privacy, specifically with the emergence of artificial super intelligence. The ability of software to learn human habits from observing and interpreting their written, verbal (and recently their nonverbal) communication is downright frightening. Corporations may know more about us than we know about ourselves. After reading this book, I started asking myself new questions: How much does the software know? How much longer before the technology can begin making decisions for us? This review focuses on sections I found most interesting from the perspective of a professor who does research in, as well as teaches courses on, information systems.

Girasa refers to Hintze's types of artificial intelligence. We are accustomed to thinking about the technology we use as reactive machines, able to help us perform tasks more quickly, efficiently and accurately. The technology itself, which really means software technology, is not learning from past experience or storing data in memory to gain experience. We assume the data are being used only for the purpose of completing specific tasks, such as developing a complex Excel spreadsheet that utilizes pivot tables and hundreds of functions to assist in reporting findings and in decision-making. The general public (on average) continues to see technology only as reactive machines.

My students are noticing how the apps they use regularly are now anticipating their needs. For example, a GPS app 'knows' when a student leaves for school in the morning and tells the student about traffic conditions and the best time to leave. Students did not choose this function nor can they toggle it on and off. I linked my students' observations with Hintze's limited memory classification whereby the GPS software is using past history of user driving habits (i.e., user data) stored in the cloud. The implication here is that AI technology is being used to understand and predict our behaviour.

The US government has been responding to the potential misuse of AI with new legislation. One problem we face, which Girasa discusses, is the shortage of people qualified in STEM subjects (science, technology, engineering and mathematics). Our need for these skills will become greater with each passing year. The government is responding by removing restrictions from immigrants who possess skills in STEM-related fields to fill the current labour gaps, creating new institutions (such as the Pentagon's joint artificial intelligence centre) and providing more funding for STEM-related training.

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One challenge we face in the US, however, is that the demand for people with the technical skills needed in the various sub-fields of AI far exceeds people who are qualified or capable. One matter I was hoping Girasa would discuss (at least briefly) is why this gap exists. Let's be honest: How many people can actually perform these highly technical tasks? Using an analogy, How many people could become effective physicians? One of the reasons we never seem to have enough physicians is that most people are simply unable to do that kind of job. This is not meant as criticism; we are each born with certain gifts and talents and not everyone is suited to medical work. The same applies to the mathematical, programming and technology-related knowledge needed to be an effective professional in artificial intelligence. These jobs are highly skilled and few can do them. I rarely see this kind of discussion in the literature

Not everyone agrees with supporting government ventures into AI research. Google and Microsoft employees have petitioned their managers to oppose AI research in the 'business of war' (Google) and in the 'integrated visual augmented system' (Microsoft). It's not hard to imagine warbased technologies integrated with AI leading to the technology itself, rather than humans, making the decision to fire. There are countless books and films on this very topic. Girasa does admit towards the end of his book that no one really knows how long it will be before machines will achieve this level of autonomy. I must admit I agree with the company executives when it comes to AI research, despite the objections of their employees. Other countries will continue to develop and leverage AI to their advantage. If the US or EU do not keep pace, they will fall far behind, vulnerable to military threat in the physical world and cyber threat in the virtual world. The Obama administration commissioned a report titled *Artificial Intelligence, Automation, and the Economy* to identify how AI disrupts the workforce and how to prepare the American economy for the widespread use of AI. The report has led to more training for the workforce, international discussions on how AI should be managed and concerns about other countries allocating enormous resources towards AI research.

In any case, I was glad to read that governments have been introducing new legislation to curtail the use of AI. We have long known that technology can replace jobs, especially low-skilled jobs and repetitive jobs. What would happen if the bulk of these jobs were automated? What would happen if higher skilled jobs were also automated? Girasa cites a McKinsey study which estimates that '47 percent of the total US employment is at high risk for replacement by automation'. Retraining such large numbers to perform tasks that are less automated (which may imply higher skilled) may be appropriate for a small percentage of workers, but retraining everyone would not be feasible.

The ethics of privacy and our control of personal information presents major challenges as people continue to increase their digital footprints in the virtual world. Although the average person may be aware of privacy being eroded, people may not be aware of the litigation in train. Take, for example, proceedings against Amazon for protection against Alexa. Just how much are these devices recording of what we say inside the home? Would you continue to use Alexa in your home? I can tell you I have disconnected mine permanently.

Facial recognition programmes, which are becoming ubiquitous, present ethical challenges. For example, software may be inherently biased against black people, or simply inaccurate. Once again, government is responding: Congress has enacted legislation requiring a 99% confidence score when facial recognition is used in law enforcement. Facial recognition software is currently being developed to interpret human non-verbal communication. Now we have computers interpreting how we feel and what we are thinking just by looking at us. Does this mean advertisers can exploit people by persuading them to buy products when they are happy rather than when they are sad?

Almost any device we purchase today can be connected to the internet. The problem citizens face is that this allows the collection of their data. One obvious example is GPS. Data must be transmitted while the GPS is in use otherwise the software could not function. But what about additional data, such as driving speed, which towns you passed through or stopped in? What about advertisements appearing on a screen whenever a driver stops at a red light? What about the selection of a vast range of preferences: a male or female voice giving directions, the language chosen, where home is?

Anything connected to the internet can also transmit data. Modern refrigerators, washing machines, televisions, cable boxes, cars, doorbells with cameras, web cams inside and outside the home, even baby monitors – all can transmit data. Government has responded by creating new legislation for informed consent, as well as making sure that people know what informed consent is. Girasa provides an example in the InModi case. Essentially, InModi claimed that its mobile advertising software tracks consumer locations only when they had opted-in (i.e., provided consent). InModi was making money by providing advertisers with location-based data from people's phones. Advertisers use such information to help tailor what they advertise to the user.

Although InMobi software did ask for permission to track from the user, the federal trade commission found InModi was tracking, with or without consent. The law may have required informed consent, but the company collected the data anyway. Furthermore, the data collected were not limited to locations; they included the history of every location the user had visited. InModi was also tracking the movements of minors, who legally cannot give consent. I am curious how InModi did not realize it was tracking the movements of minors since the AI would reflect advertising of products in their age group. These details were not discussed in the book. How do we, as citizens, respond to this? InModi was fined \$US950,000 and its practice of collecting data illegally was ended. In my opinion, the fine was not sufficiently severe. In the EU, privacy legislation provides for far greater penalties.

What about the application of AI to text? We already have text mining software. Girasa mentions Google assistant, a technology that can translate what is being said in real time. We have devices that can translate more than 60 languages while listening to someone speaking in a different language. AI is needed for this function, which implies that conversations must be recorded over long periods for the algorithms to learn how to translate. What would happen if the AI became too intelligent for our own good? Corporations and governments are eager to aggregate all this data to learn more about people. Large corporations and the government could have massive power over our lives. They can aggregate data from many sources and feed the result into AI for analysis.

Girasa cites Erzoni: 'AI practitioners should take an oath analogous to the Hippocratic Oath taken by doctors.' Professionals in the field have both enthusiasm for, and genuine fear of, AI. Girasa highlights an ongoing debate about the fear of robots taking over and discusses Asimov's three laws of robotics. Given advances in robotics and in artificial intelligence, now capable of abstract reasoning and interpreting non-verbal communication, Asimov's laws are moving from science fiction to the real world.

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# **BOOK REVIEW**

**The Market in Mind: How Financialization Is Shaping Neuroscience, Translational Medicine and Innovation in Biotechnology** by Mark Dennis Robinson (2019) xiv + 309pp., \$US40.00 (paperback) MIT Press, Cambridge MA, ISBN 978-0-262-53687-5

Translating discoveries from the laboratory so that they become beneficial for health is a major challenge in biomedical innovation. The process is costly, uncertain and very risky, the realm of governments and large pharmaceutical companies. The innovation system shaping neuroscience, medicine and biotechnology is complex and obscure in many respects.

This book is about the emergence of translational science and medicine in the West, part of a tectonic shift that has quietly reconfigured the landscape of biomedical research in the West. Despite many definitions accorded to translational science and medicine (TSM), they share a core thread – that biomedical research must be dramatically reorganized to accelerate the transformation of research discovered in laboratories into medical products, including diagnostics, medicines, and technologies' (p.vii).

Robinson, from Harvard Law School and Creighton University, states that his initial project began as an effort to understand the local transformations of contemporary neuroscience laboratories after the 'decade of the brain'. Instead, he uncovered a distinctly 'translational turn' that was to shape the direction of his ongoing work. This translational turn is the idea that the aim of research is to translate findings as quickly as possible into medical products. Robinson commences his narrative with an event in 2012 where the US National Institutes of Health (NIH) quietly set up a new pilot program, Discovering New Therapeutic Uses for Existing Molecules, to promote just that. The initiative has proven to be more than wishful thinking. TSM has evolved into a set of 'realized objects - professorships, funding schemes, TSM centers and graduate programs (including nearly 60 new US programs in translational science in 2017)' (p.vii). The rationale for these changes is often promoted with the grand claim that they will benefit the world's sick. Robinson's agenda is to explore the consequences of this momentous, but surprisingly unheralded, policy and structural development. In effect, universities are being asked to share an increasing burden of risk in participating in translational relationships. One consequence is that the dictates of finance are now shaping the science and indeed the notion of health itself. Despite being promoted as solely about health or innovation, translation becomes an economic configuration, a means of rehabilitating failed, risk-laden pharmaceutical market strategies and delivering shareholder value (p.229).

*The Market in Mind* is a particularly revealing book, exposing the multi-variant nature of innovation as a social process. This is achieved though Robinson's interdisciplinary research approach, which is underpinned by ethnography and a very close reading of context. He develops a persuasive, rich, contemporary narrative located within the science and technology studies genre. In fact, it is an excellent example of what can be achieved by using such an eclectic scholarly approach. Robinson draws on facts and figures for evidence and to good effect, but his real strength is his ability to deconstruct and analyse interviews, political speeches and significant translational events, such as investor conferences where scientific possibilities are given meaning to a potential set of investors. Translation is not just about laboratory ideas moving to market, it is also about 'imaginings', rhetoric, marketing and shareholder value, to name but a few of its dimensions. An example of Robinson's ability to analyse is the revealing way he exposes the lines of argument drawn from a campaign comment in 2008 from Sarah Palin, the Republican vice presidential candidate in the US. Essentially, Palin informed her audience that 'sometimes these dollars [going to translational neuroscience], they go to projects having little or nothing to do with the public good. Things like

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*fruit fly* research in Paris, France' (p.30). The fact (probably unknown to Palin) is that fruit fly research is actually important to understanding cures for degenerative diseases. What Robinson exposes from Palin is an anti-intellectualism in populist thinking that regards non-application focused knowledge as valueless. Robinson points out in a very considered and educative way that the history of TSM intersects with long-standing debates about public investments in research and the demands that such investments produce results benefiting the larger public. It is this sort of sentiment that provides the legislative warrant associated with application-oriented demands made by the state. This goes some way towards explaining the sudden emergence of TSM (p.33). The book's strength is built on numerous such scholarly insights to make a persuasive case for how financialization is shaping research agendas and health outcomes.

The book's introduction opens with an interview with a leading industry expert from a market analysis firm that focuses on translational neuroscience (TN) – a particular mode of neuroscience research focused on accelerating the development of novel brain technologies, such as psychopharmaceuticals, diagnostics and devices. TN, a case study within TSM, develops as a central theme in the book. The introduction establishes that what is at stake here is not just a form of economic reorientation of research, but also a trend that has profound ethical implications.

Robinson then justifies his preference for interpreting translation using a political economic view. He provides context for the relatively rapid emergence of TN and TSM. Robinson claims that semipermanent commercial architectures confer durability onto translational aims, which distinguishes TSM from prior efforts to produce application-oriented work from federal funds and university research (p.30). TN is not just a matter of innovation and its glittering narratives; it must be understood in relation to a strategy undertaken by biopharmaceutical companies, which outsource the riskiest parts of early-stage neuroscience R&D to universities.

Chapter 4 examines how the work done in translational laboratories is understood as innovation in health. Robinson relies on discourse to make his case, but he extends his analysis to include architectures and software. The latter gives material expression to how translational research becomes constituted as innovation in health (p.97). While the university and medical centres are positioned as the *de facto* spaces for TSM, much of the work of translation happens behind closed doors in spaces and networks occupied by investors, entrepreneurs and biopharmaceutical executives.

Robinson next explores how investor networking events operate as *de facto* laboratories where scientific problems get worked out, relationships between investors and scientists are arranged and various kinds of neuroscience activity are understood as meaningful and valuable (p.145). Robinson claims these events are theatres of epistemology and value. For example, patient subjects can be reconstituted as biological parts – they become 'partial subjects' (p.145). Likewise, sole focus on biomarkers can direct attention away from the 'broader social, political and economic conditions that produce the conditions for which biomedicine is summoned as a totalizing solution' (p.201). This is followed by the reminder that TSM is the product of many histories and has many facets. While TSM is often justified in the name of putting patients first, this need not be the case. Robinson recounts his experiences in the field at the Cleveland clinic in Ohio. He builds a picture of the marginalization of patient voices in TN as well as the complex relationship between TN and the clinic.

The book's conclusion affords Robinson an opportunity to expand on his analysis with an ambitious set of areas for further investigation. For example, Robinson asks, is translation a success? Well, on the one hand, TSM might be a long game, meaning that it could take many years for its potential to be realized. On the other hand, as Robinson suggests, it might be a fully realized financial outcome (p.230). Even where there has been no actual innovation or improvement in patient health, the various strategies of TSM can deliver outcomes that increase returns to shareholder value.

The book is US-centric even though the claim is made that TSM is now a well-established phenomenon in the West. This may be true, but it is not a claim the author justifies in his book. It could be that TSM does not copy exactly across policy domains in other countries. For instance,

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how is this form of innovation shaped by social forces in China or, say, India? Likewise, some of the sentiments in the book could grate with some researchers. I can imagine well-intentioned researchers considering Robinson's arguments trite: TSM has been around for years; some areas of investigation are so complex and fundamental understanding is so remote that rational treatments cannot be found, so they are left alone; some universities may engage with patients and the public so that the moral implications of their work are understood, it is just that there are too many diseases to be cured with too little time and dwindling resources. Nevertheless, the book raises a number of pertinent points which are even more relevant in a world troubled by the COVID-19 pandemic. *The Market in Mind* is a scholarly work and its message so important that it deserves a wide readership. The book provides a clear demonstration of the social shaping of science, technology and innovation. I recommend it highly.

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# **BOOK REVIEW**

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**Capital, Investment and Innovation in the Roman World** edited by Paul Erdkamp, Koenraad Verboven and Arjan Zuiderhoek (2020) 512pp., £100 (hardback) Oxford University Press, Oxford, ISBN: 9780198841845

The study of ancient economy presents considerable difficulties. In his masterpiece, *The Ancient Economy*, Moses Finley (1973) captures the complex economic and social dynamics of the ancient world, clarifying how the uncritical application of modern economic theory could become misleading in a world pervaded by social ties, religious beliefs and where the concept of status was more important than economic rationality. In the light of this valid argument, ancient economy has often been interpreted, whether rightly or wrongly, through the lens of economic irrationality. The strict application of this approach has implicitly relegated the role of innovation and commercial and mercantile activities to exceptional cases or phenomena of little importance. This excess of prudence has distorted the image of the classical world and its economy. Since the 1990s, a range of new archaeological discoveries has allowed a re-evaluation of the role of capital, innovation and investment in the ancient world, throwing new light on an economy far from stagnant and renewing the need to cast away some preconceptions and forced readings. However, there is a risk of becoming bogged down in a revival of the debate between primitivists and modernists; a dispute in which both sides try to emphasize the presence or absence of evidence to support their thesis, transforming the debate into a series of useless quarrels.

The aim of this book is different, positioned in that grey area that has recently garnered much interest from the majority of ancient historians. Released from the strict frameworks of primitivism or modernism, the book offers a collection of very recent essays on a series of aspects of the Roman economy that are rarely recognized: the role of capital, investment and innovation in the Roman world. In detail, the book focuses on privately provided capital, elite investments and on the role of context in the innovation process. This is all accomplished without forgetting to provide contextual reading key to the arguments, references which are not limited to long lists of archaeological discoveries. The book is structured in three sections, the first dedicated to investment and innovation (chapters 2 to 6), the second to the role of capital and credit markets (chapters 11 to 15). Our review will focus more on essays dealing with innovation or its practical applications in the agricultural sector, leaving out the third section on credit markets and human capital.

In their introduction, Erkdamp, Verboven and Zuiderhoek point out that the dichotomy between status and economic interest is not always strictly respected; the two components are often intertwined. In the Roman world, this was not always because of the introduction of technical applications, as happened in the industrial revolution, but was a result of the law and institutions. Roman law continuously developed tools in response to the needs of commerce and other economic activities. The increase in connectivity resulting from the great extension of the Roman empire allowed the development of economies of scale and a considerable increase in standardization. These phenomena were not exclusively a result of new technological discoveries, but involved the use of existing techniques that became convenient in this exceptional economic context. In the ancient world, the context of innovation mattered more than innovation itself. For example, improvements in ship transport were more a consequence of improvements in port infrastructure than of improvements in ship technology. The scale and standardization in which these constructions operated was innovative.

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In the second chapter, Paul Erdkamp shows how the application of technologies, such as hydraulic power mills, and the presence of a moderately large agricultural sector were able to free the Roman world from the Malthusian trap that many scholars attribute to pre-industrial societies. The high population density in the large Roman metropolises and the proximity of skilled workers within the cities stimulated the spread of innovation through learning by doing. The growth of the population not only stimulated technical progress, but also the spread of ideas. Erdkamp explores how the great extent of the Roman economy created the incentives for the application of inventions already known for centuries, as in the case of naval technology or animal traction. Not surprisingly, many technologies were lost after antiquity following the collapse of markets and distribution structures that made them convenient.

Cristiano Viglietti illustrates how the narration of an archaic Rome economy, from the eighth to the fourth century BCE, based only on the spoils of war, is misleading. The innovations of agriculture, the introduction of metal tools, draught animals and crop rotation were the basis of the process of development from nomadic to sedentary of the early Romans, which allowed the urbanization of Rome. These transformations increased the inequalities within archaic Roman society and the division into classes, allowing the elite to sell their surplus in a rising agricultural market. According to the author, the increase in tithes paid following the increase in trade flows, together with the acquisition of the spoils of war, allowed the construction of the temple of Jupiter, the *Cloaca Maxima* and other important infrastructures.

Wim Broekaert and Arjan Zuiderhoek focus their analysis on the role of capital goods in the Roman economy from the late republic to the first empire. Capital goods were present in agriculture (farmhouses, barns, sheds, stables, etc.). Although they were often self-produced, these required investments for their purchase, repair or replacement, making investments in capital goods an important component of the Roman agricultural sector. This was particularly evident in the large estates owned by the elite. In addition, the presence of investments in capital goods indicates a connection with markets. As for maritime trade, the authors re-elaborate Rathbone's estimates (2003) of the cost of equipping merchant ships, including variable costs and assuming a ship's life of between 10 and 20 years. In the light of these estimates, the authors support the hypothesis that the elites were also involved, through substantial investment, in these activities, despite moral sanctions and prohibitions (such as the *plebiscitum Claudianum*) preventing them trading by sea. The same conclusions are reached with regard to urban production, where both the capital needed to set up a store and the raw materials were often borrowed from the elite.

Andrew Wilson offers a vast overview, through archaeological and historiographical evidence, of the use of water-powered mills in the Roman world, offering effective counter-arguments to those who see in the classical era a period of technological stagnation. In the light of the most recent archaeological discoveries, Wilson concludes that the diffusion of mills in the Roman world, in particular between the first and third century CE, was extensive. Large infrastructures with even 16-wheel mills have been discovered in Gaul and Turkey. Water-powered mills were used not only for grinding grain, but also for tanning, crushing metals and removing sawdust from stone and wood. The technology applied in the mills is to be dated before the Roman period, but its application on a large scale is under the aegis of the Caesars. Wilson suggests that this degree of diffusion and technological sophistication disappeared after the collapse of the western Roman empire (while it remained longer in the eastern one) and reappeared, albeit in less efficient forms, only in the late middle ages.

In an archaeological study, Nicolas Monteix investigates capital, investment and innovation in the urban context. Through an overview of the various components of urban capital, Monteix comes to the conclusion that the factor that most mobilized capital was start-up cost, a factor that was in proportion to the size of the enterprise. Providing that the nature of the activity remained unchanged, the extension and modification of initial installation necessarily involved less capital, thanks to the particular adaptability of the assets in antiquity and their low degree

of wear. In a broader perspective, one must keep in mind that the low standardization of the ancient world had its obvious consequences. For example, ceramic containers could be adapted to other purposes than the original uses; for example, as domes for furnaces. This, on a larger scale, made it possible to optimize pre-existing capital whose first life had run its course. Moreover, the possible problems connected to the supply of durable raw materials for the whole year resulted in a partial immobilization of the assets and therefore of the capital. The qualitative transformation of the means of production (innovation) is particularly difficult to identify. The wooden barrel is one of the major innovations in the field of transport. Its adoption can be observed, with a considerable regional variation, only through the decrease in amphorae findings. This reasoning can also be applied to the slow evolution of the loom between the end of the republic and the first empire, where adoption of the kneading machine to make bread provides another example. Although not universal, the contribution of innovation remains a question that cannot be answered. In conclusion, the author states that, despite the difficulties involved in the study of capital, innovation and investment, qualitative and quantitative diversity (investment), almost ignored in the past, should be interpreted as an indicator and force generator of the urban economy.

Marguerite Ronin deals with the financing of irrigation. From the second century BCE onward, demand resulting from the rapid growth of urban markets expanded. In this context, irrigation allows greater productivity and thus the possibility of greater profits. A high degree of sophistication can be explained by the spread of Greek and Carthaginian intensive farming techniques, including convertible husbandry (alternate arable and pasture on the same piece of land). The expectation of high profits in agriculture was clearly why landowners equipped themselves with irrigation tanks. It seems, at first glance, that some irrigation infrastructure was quite basic and required little engineering knowledge. So, the only investment was in manpower. However, in some cases, engineers were still required and this involved a financial investment, the amount of which depended on the length of the construction, but also on the availability of water sources. Scarcity or distance may have led landowners to invest collectively and share infrastructure. Irrigation associations are rural associations that come together to share a common source of water. It should be noted that the documentation of these organizations comes from Africa and Spain, two dry regions where irrigation would have been crucial to ensure sufficient production.

Mick Stringer offers a chronological reading of the most important authors of practical manuals of antiquity – Cato, Varro and Columella. The author states that Varro's main concern is the creation of *fructus*, and that the need to choose between financial and non-financial outcomes simply does not manifest itself. Only Columella seems able to distinguish between investment outlay and running costs. Moreover, none of the three clearly distinguishes among sales income, gross profit and net profits. Therefore, none is likely to have produced structured hierarchies, or profit and loss calculations. Columella, with his extensive use of the term *reditus*, may be the exception with his concept of a net cash return for a fixed investment. His employment of *aes, expedit* and *utilis* suggests that he associates these more with the development of vineyards and the products of *pastio villatica* than with the production of wheat and oil. Wheat and oil production were seen as a moral imperative, while wine and bakery products were developed to meet market demand, so they represent investment choices. The development of the mentality of the three agronomists is consistent with the wide economic changes of the period.

In the ninth chapter, Annalisa Marzano investigates the factors that govern the allocation and exploitation of natural resources. Fishing, affirms the author, could have had an important role in the economic development of the coastal communities. Legal sources tell us that the elites tried to control fishing activities to their own advantage, even going against the establishment of legal procedures, and that non-prominent individuals could defend their rights only if they organized themselves as a group, and if their patron could guarantee them legal mediation and a hearing for a petition. Only communities that had the opportunity of a direct and personal dialogue with significant representatives of Roman authority could have any hope of asserting their rights to natural

resources and tax exemption. The legal and administrative structure was not sufficiently developed to ensure that rights were automatically guaranteed and abuse by taxpayers was common, especially when profit expectations were high.

A broad overview of the role of innovation in oil and wine pressing systems is provided by Tamara Lewit. She shows how the idea of a chronological development of press technology is misleading. The various types of presses evolved within a regional context rather than uniformly and were not the result of widespread invention from a central place. However, this does not mean that innovation did not take place. The archaeological evidence shows enormous regional diversity and the development of a multitude of local solutions to various technological problems. Innovation was neither absent, nor linear or one-dimensional, but rather multi-directional. Economic historians have focused almost exclusively on innovation in the shape of screw presses. However, the assumption that the introduction of screw presses produced an increase in productivity is a simplification. Ethnographic studies, mechanical calculations and reconstructions suggest that the use of a screw did not significantly increase the amount of liquid extracted from a fruit, a change that happened only when metal presses and new energy sources (hydraulic or fossil fuel) were developed in the late nineteen or twentieth centuries. Only by increasing the tonnage and weight of the presses would it have been possible to process a greater quantity of fruit; a solution that we see applied in Tunisia and Tripolitania. This multiplication of presses is a phenomenon that appears in both Africa and other provinces. However, the introduction of the screw press makes pressing easier and safer. In terms of work, the mechanical advantage of the screw could reduce the effort of lifting the weight with the winch, the main feature of the lever press. On the other hand, all forms of screw press required more personnel. Ancient screw presses were identified more in urban contexts, where space was scarce. A screw press did not necessarily extract more product, or exert more pressure, or use the labour factor more effectively than a screwless press. It also required more manpower, but saved space and used less material.

Finally, the book is accompanied by interesting graphs and tables and by a considerable and well-explained quantitative section. In addition, the use of photographs and drawings is of great help to those who are not experts in archaeology. The book continually draws on the most recent literature, which makes it a work of great interest for economic historians, among others, who want to study these topics at a more nuanced and detailed level. Furthermore, this book provides some useful suggestions for modern economic innovation theory. First, the high level of diffusion and sophistication of innovation in the Roman world confirms the importance of political stability and economic integration for the spread and development of ideas and technology. Within the Roman empire, technological progress derived mainly from law and institutions and from the high level of connectivity allowed by such infrastructure as roads and harbours infrastructure. In addition, the standardization reached during this period and scale economies are associated with the exceptional extension of the Roman empire, showing the importance of access to wide markets for the spread of capital, investment, innovation and consequently for economic growth. However, I found the decision (well-argued in the introduction) to focus almost exclusively on the private sector, leaving aside the Roman state economy, not to be appropriate if the aim is an overview of the role of capital, investment and innovation in the Roman economy tout court.

Several times while reading the book, I had the feeling that the state component was minimal within the Roman economy; which is just not true. This ignores the role of regulated markets, the command economy and the army (see Whittaker, 1988). It might have been an idea to include a section on the relations among capital, investment, innovation, the command economy and the regulated market. For example, the presence of a regulated grain market (the *annona*, aiming to supply urban populations) could affect grain prices and, consequently, whether the private sector chose to invest in grain. In addition, the Roman empire was founded on military power and the army was an important economic actor within the Roman world (Hertz, 2007). The economic activity behind the supplies for the legions and the role of the army in the building of infrastructure were factors that strongly stimulated capital, investment and innovation.

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# **BOOK REVIEW**

**Innovation, Ethics and Our Common Futures: A Collaborative Philosophy** by Rafael Ziegler (2020) 193pp., £75 (hardback) Edward Elgar, Cheltenham, ISBN: 978 1 78990 453 6

Innovation and sustainability are ubiquitous in the academic and political discourse. They both seem to be something to which no reasonable person would openly object. They also appear to be complementary: the report that brought sustainable development to the top of the international agenda stresses that more innovation tends to lead to a greener economy (World Commission on Environment and Development, 1987). However, this should not hide two major issues: (1) difficulty in finding a consensual definition for these two notions, and (2) tensions between them when innovation contributes to unsustainable outcomes, such as biodiversity loss and climate change, and when sustainability requires going beyond technological innovation to change our attitudes and lifestyles.

Rafael Ziegler's book explores the complex relations between sustainability and innovation. It brings together the two emerging fields of innovation ethics and sustainability ethics to nuance the optimism of the Brundtland report (World Commission on Environment and Development, 1987) and to highlight that varieties of innovation can lead to a variety of common futures. According to Ziegler (p.7), in both public perception and the academic literature, there is a strong and prevalent pro-innovation bias. In our innovation societies, innovation (understood as technological novelty for commercial use) is usually conceived as inherently good. The notion of innovation has received surprisingly little criticism and remains a 'conceptual blind spot' (p.9) in the literature. The objective of the book is to fill this research gap by investigating ethical approaches to innovation.

The literature usually sees innovation as *economic* innovation, understood as the realization of a new idea through entrepreneurial action in order to create a product or service for markets and thereby contribute to economic development and the raising of standards of living (pp.44–5). Although there is still no established philosophy of innovation on which one can build a more critical approach, multiple adjectives to qualify innovation, such as sustainable, social, responsible, free and frugal indicate a discontent with innovation tout court. Social innovation, perhaps the most generic of reflexive forms of innovation, for instance, includes two major kinds of innovation that go beyond technological and economic innovation and connect with sustainability. There is democratic innovation (pp.52-3, 162-3), such as civil disobedience actions by Extinction Rebellion and Fridays for Future that respond to government failure and push for more ambitious collective actions against climate change. There is political innovation (pp.54, 160-1), such as institutional reform proposals that aim to take the interests of future people (González-Ricoy and Gosseries, 2016) and sentient animals (Donaldson and Kymlicka, 2011) into account by changing decision-making structures and current perceptions. Resistance, political opposition and the promotion of more just institutions through citizenship participation can all be conceived as civic forms of innovation in a green republican perspective (pp.126-8).

These new, more reflexive notions of innovation help us understand that 'innovation is not only a matter of technology for markets' (p.55), but at the same time they 'all tend to reinforce the proinnovation bias' (p.147). This is confirmed by Blok and Lemmens (2015, p.31), who explain that the literature on responsible innovation is dominated by a techno-economic paradigm, according to which innovation represents a '(1) technological innovation, (2) primarily perceived from an economic perspective, (3) inherently good, and (4) [that] presupposes a symmetry between moral agents and moral addressees'. How to find an alternative to this pervasive techno-economic conception of innovation?

To my mind, the most original contribution of Ziegler comes from his drawing on theories of justice to find a more satisfactory, critical approach to innovation. A first candidate is the liberal

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egalitarian perspective. In *A Theory of Justice*, Rawls (1999, pp. 251–8) proposes a two-stage model of intergenerational justice in which a phase of capital accumulation to raise the standard of civilization and culture is followed by a steady-state phase once just institutions have been firmly established. Ziegler proposes complementing this Rawlsian perspective by restating the just savings principle as a just investment principle (pp.81, 85): each generation has a duty not only to create and preserve just institutions, but also to invest in innovation missions that address the main societal challenges arising from the process of culture and civilization. This re-statement pushes policymakers to consider both innovation and 'exnovation'; that is, the deliberate phasing out of some technologies, such as fossil fuel energy structures, that threaten the long-term stability of society.

This liberal approach has the merit of bringing intergenerational justice and sustainability ethics together, in the same spirit as Konrad Ott's Rawlsian perspective (Ott, 2014). I would, however, stress that this approach is not a mere restatement of Rawls's just saving principle; it goes beyond Rawls in at least two ways. First, Rawls was not interested in environmental or sustainability ethics. One of the only places where he mentions 'our relations with animals and nature' is to specify that dealing with this topic is '[o]ne of the tasks of metaphysics': environmental issues such as 'the destruction of a whole species' can indeed 'be a great evil', but they are beyond the 'limits of a theory of justice' (Rawls, 1999, p.448). Second, Rawls is famous for restricting his theory of distributive justice to national borders: his duty of justice at the international level is merely one of assistance towards burdened societies. This country-to-country approach cannot cope with our most pressing ecological issues, such as climate change and biodiversity loss, which are genuinely global problems requiring collective action (Gardiner, 2011). This calls into question the merits of the Rawlsian approach to sustainable innovation.

Ziegler is aware of some of these limitations when he stresses that philosophical liberalism in general, and the Rawlsian approach in particular, are largely dependent on the economic conception of innovation and on the pro-technological bias. This is why he moves to a more fine-grained evaluation of the impacts of innovation: the capabilities approach, which focuses less on resources and more on people's substantial freedoms to choose those things they value as the currency of justice. This approach has the advantage of explicitly emphasizing the importance of environmental sustainability in the realization of justice. Ziegler draws here on Sen and Nussbaum. Sen stresses that differences in personal traits and in social and environmental contexts make a real difference for the freedom of individuals (p.102). In her list of basic, cross-cultural capabilities that establishes a threshold of minimal justice, Nussbaum mentions the ability to live with concern for, and in relation to, other species (p.19). To get a full picture, we could also add Holland's crucial contribution, which expands Nussbaum's list with sustainable ecological capacity as a meta-capability to highlight that each basic capability relies on specific ecological conditions, such as climate stability (Holland, 2008).

Ziegler announces from the start that he will adopt, as he did in previous publications, the capabilities approach (p.19) and this becomes clear when he proposes his model of nature-respecting sufficiency (pp.153–5). This model relies on four principles: (1) self-preservation, which makes it permissible for moral agents to foster and secure their central capabilities; (2) proportionality, which gives priority to central capabilities; (3) minimum wrong, which requires moral agents to minimize harm when they pursue self-preservation; and (4) restitutive justice, which requires moral agents to make up for harm that has not been avoided. The link with the capabilities approach and the idea of a lower threshold to secure basic capabilities or protect human dignity is explicit, especially in (1) and (2). I would, however, like to suggest that this model could and should draw on two other theories of justice that are neglected in the book.

The first of these is left-libertarianism, which also focuses on real freedom for all (Van Parijs, 1997), and is particularly interested in one tool, the universal basic income (UBI), a universal and unconditional individual cash transfer. Ziegler mentions this tool in passing (p.156), but does not develop the idea. This comes as a surprise, since a UBI can be a powerful way to institutionalize (1) and (2) and to guarantee that everyone has enough. Van Parijs and Vanderborght (2017) have recently developed a comprehensive account of the UBI, which could be a way to implement the

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model of nature-respecting sufficiency. The articulation between this theoretical model and practical tools to implement it remains underexplored in Ziegler's book. Some scholars have proposed as a variation of the UBI an economic or ecological transition income (ETI), an incentive for recipients to build more sustainable ways of life (Johnson, 2011; Swaton, 2018). This also seems to be a promising way to institutionalize a sustainable form of innovation.

The second approach, one that plays an implicit role in (3) and (4), is limitarianism, setting an upper threshold to the wealth and environmental footprint of individuals in order to reduce their contribution to global inequalities and harms (Robeyns, 2017). While the capabilities approach focuses on the criteria for having *enough*, limitarianism is more interested in the conditions for not having *too much*. Ziegler mentions this approach when he stresses that inequalities should be reduced because they undermine central capabilities (p.157), but he does not explicitly adopt limitarianism (at least not as clearly as he supports the capabilities approach). There is ample room to develop the idea that individuals' use of natural resources should be limited by an upper threshold, since *wealth* limitarianism (Kramm and Robeyns, 2020) has so far not been complemented by *ecological* limitarianism.

These are just two suggestions for further developing the nature-respecting sufficiency model, which represents a highly relevant approach to bring together innovation ethics and sustainability ethics. Both fields address pressing philosophical concerns; Ziegler makes a brilliant contribution to the investigation of some of the most urgent ethical issues of the twenty-first century.

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