Original Article - Contested terrains

ELRR

i4.0, 3D printing, deglobalisation and new manufacturing clusters: The view from Australia

The Economic and Labour Relations Review
2021, Vol. 32(1) 115–133

DOI: 10.1177/1035304620981429
journals.sagepub.com/home/elra
SAGE

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Abstract

Before the COVID-19 pandemic erupted onto the world stage, a new narrative was apparently beginning to emerge about the impact of i4.0 and new technologies in general, and three-dimensional printing in particular, on the future of work and employment. This was to have particular geographical implications for the manufacturing sector in particular. Proponents of i4.0 also suggested that this process, particularly in manufacturing, would promote the re-emergence of patterns of clustering. Developments in advanced manufacturing, particularly three-dimensional printing, would accelerate and reinforce these tendencies. This article looks at the role that three-dimensional printing is supposed to play in the new world, and in particular, critically evaluates its role in reinforcing the trend towards deglobalisation on the one hand, and, on the other, new clusters of manufacturing industry.

JEL code: O33

Keywords

Advanced manufacturing, fourth industrial revolution, i4.0, manufacturing clusters, nearshoring, new technologies, platform capitalism, three-dimensional printing

Introduction

In earlier work (Rainnie and Dean, 2020), I looked critically at the emerging i4.0 debate and how it related (or didn't) to the literature on the future of work, with a particular

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focus on Australia. In this article, I return to 94.0, but look at the supposed role of three-dimensional (3D) printing in the new world. In particular, I draw on work looking at the new geographies of artificial intelligence (AI) and Platform Capitalism and also work on New Urban Spaces (Brenner, 2019) and Extreme Cities (Dawson, 2019).

A 2018 report for the World Bank suggested that the future manufacturing landscape would be influenced by megatrends including demographic change, urbanisation and climate change (Hallaway-Driemeir and Nayyar, 2017: 79). Donald and Gray (2019) argue the existence of a diabolical double-crisis encompassing both a deep financial crisis and environmental one and suggest that academic regional studies downplay the scale, scope and nature of this crisis. Cities have tended to be overlooked in some debates on, for example, Global Value Chains (GVCs) and uneven development. Yet as Dawson (2019: 4) argues, cities are the defining social and ecological phenomenon of the 21st century; housing the majority of humanity, contributing the lion's share of carbon to the atmosphere, and being peculiarly vulnerable to climate chaos. A focus on cities is particularly important in Australia, given the concentration of much of the country's population in a small number of state capitals.

At a much more local level, before the COVID-19 pandemic erupted onto the world stage, a new narrative was emerging about the impact of i4.0 and new technologies in general, and 3D printing in particular, on the future of work and employment. This was to have particular geographical implications for the manufacturing sector especially.

The global economy was not in good shape before the advent of Coronavirus-19. There was growing discussion of what was coming to be called 'deglobalisation' (Pegoraro et al., 2019). This was evidenced, first, by the rise of nationalist and increasingly protectionist governments across the world, and second, by a restructuring of the seemingly all encompassing GVCs. GVCs had been accepted by the major institutions of the world economy (International Monetary Fund (IMF), World Bank, International Labour Organisation (ILO), World Economic Forum (WEF) etc.) as the main drivers of economic activity. The rising predominance of GVCs was seen as driving a particular pattern to the spatial division of labour at a global level, but it was increasingly argued that these chains had become overstretched, and, for a number of reasons, were undertaking a relocation process (near- or reshoring) that brought production processes back closer to major markets (Kinkel, 2020). This process, it was argued, was accelerated by the increasing adoption of new technologies (AI, robotics and 3D printing) that had important implications for the number and nature of jobs in the new units (Pittarello et al., 2020).

Proponents of i4.0 also suggested that this process, particularly in manufacturing, would promote the re-emergence of patterns of clustering, similar to those supposedly exhibited in post-Fordist industrial structures. Developments in advanced manufacturing, particularly 3D printing, would accelerate and reinforce these tendencies (De Propris and Bailey, 2020: 33; Bellandi et al., 2020). For the WEF 2018 Future of Jobs Report, 3D printing is just one of many ways whereby companies intend to take part in a fourth industrial revolution that is both desired and feared (Polli, 2018: 2).

In questioning this new orthodoxy, I develop a critical evaluation of the role of 3D printing in reinforcing the assumed trend towards deglobalisation on the one hand, and on the other, new clusters of manufacturing industry. In so doing, I examine broader processes that are intensifying uneven development, socio-spatial exclusion and territorial disparities across spatial scales.

An early insight

As Gress and Kalafsky (2015: 43) have pointed out, as early as 2012 *The Economist* had labelled 3D printing as heralding a major transformation in manufacturing. In discussions of 'spatial leapfrogging', new locations of economic activity and innovation were seen as emerging, leading to what Gress and Kalafsky (2015: 44) suggested might amount to a 'Schumpeterian surfboard riding a Kondratiev-like wave in the manufacturing sector and its numerous supporting service industries'.

There is a complex geography associated with 3D printing. In the first instance, the machinery itself is still likely to be manufactured within a select number of locations. There remained, however, the question what was printed and where. Heavy and batch manufacturing was not going to be replaced for the foreseeable future for two reasons. First, such forms of manufacturing would continue to migrate to low-cost locations. Second, at the opposite end of the spectrum, higher value-added manufacturing with relatively long runs would remain in certain locations through considerations including human capital and support infrastructure. Furthermore, much of the upstream supply of raw materials would still need to be extracted, processed and transported. In other words, established extractive industry production networks would remain crucial.

Gress and Kalafsky (2015: 46) argue that additive manufacturing technologies 'will inevitably foster new geographies of innovation'. First, as prototypes can be manufactured quickly much closer to sources of research and design. Second, knowledge synergies coupled with the demand situation serve to reinforce existing clusters, or indeed take root in other locations. Two divergent geographies of manufacturing may emerge. Relatively large batch, cost-sensitive production and final assembly will continue with traditional forms of manufacturing but downstream manufacturing of replacement parts may be diverted. Alternatively, small batch and customised parts may be designed and printed for consumption in developed markets, bypassing traditional logistics routes.

However, Gress and Kafalsky (2015: 51) warn against sweeping generalisations about revolutionary changes in the geography of manufacturing, preferring to suggest that '[l] ooking forward, it does appear that in some regards additive manufacturing has the potential to change certain facets of manufacturing and innovation, and as a result, some of the spaces of production'.

This warning has not been heeded by many proponents of the emerging new orthodoxy. In the next section I look in more detail at what 3D printing actually entails.

3D printing

The term '3D printing' covers a host of processes and technologies that claim to offer a full spectrum of capabilities for the production of parts and products in different materials. What all the processes and technologies have in common is the manner in which production is carried out layer by layer in an additive process, in contrast to traditional methods which involve subtractive methods or moulding/casting processes. Traditional methods can require expensive tooling, fixtures and the need for assembly for complex parts. In addition, subtractive processes can involve much waste of standard materials. 3D printing, it is suggested, reduces prohibitive costs and lead times. It is also emerging as an energy-efficient technology that can provide environmental efficiencies in terms of the manufacturing process itself, utilising up to 90% of standard materials, and throughout the product's operating life, through lighter and stronger design (3D Printing Industry (3DPI), 2020: 5).

3DPI define 3D printing as,

> . . . a process for making a physical object from a three-dimensional digital model, typically by laying down a number of successive thin layers of a material. It brings a digital object (its CAD representation) into its physical form by adding layer by layer of materials . . . 3D printing brings together two fundamental innovations: the manipulation of objects in their digital format and the manufacturing of new shapes by addition of material. (p. 3)

A range of processes and materials are involved. Processes include stereolithography, digital light processing, laser sintering/laser melting, extrusion (fused deposit modelling, freeform fabrication), inkjet, selective deposition lamination, and electron beam melting. There is now a wide variety of different material types, supplied in different states – powder, filament, pellets, granules and resins. Materials include plastics, metals, ceramics, paper, bio materials and food.

3DPI claim that additive manufacturing can eliminate the need for tool production and therefore the costs, lead times and labour associated with it. Furthermore, because products and components can be designed specifically to avoid assembly requirements, this further removes labour and costs associated with assembly processes.

Again, according to industry sources, 3D printing has both business and technical benefits. With a metal 3D printer, it is possible to quickly and affordably prototype functional parts and help produce tools that speed up production. Furthermore, this compresses time lines, thus reducing necessary labour, time and money (Markforged, 2020).

According to 3DPI (2020), the nature of the technology permits new ways of thinking in terms of economic, environmental, and security implications of manufacturing, with (it is claimed) 'universally favourable results'. Echoing the increasingly accepted conventional wisdom, it is argued that

> The shift of production and distribution from the current model to a localized production based on-demand, on site, customized production model could potentially reduce the imbalance between export and import countries.

In a 2020 industry survey of the printing industry job market, with over 1600 respondents, nearly 90% were male and over 60% had an engineering background, with nearly half having at least a Masters level degree. Engineers, technicians, sales and marketing were the most in-demand profiles for hiring in 3D printing. Over half said that a knowledge gap would limit the adoption of technology. Perhaps unsurprisingly, over 60% of respondents had learned 3D printing on the job, and over a third of respondents said that the 3D industry needed more training and education programmes to grow (Sculpteo, 2020). The same survey suggested that women only made up around 13% of the sector's workforce, concentrated in sales and marketing, and to a lesser extent, research.

However, as we shall see, the new orthodoxy has built an elaborate superstructure without a detailed analysis of 3D printing itself.

GVCs and 3DP: Clusters (again)?

A 2017 report for the World Bank on the future of manufacturing argued that trends affecting the geography of production would come from changing globalisation dynamics (deglobalisation) and emerging technologies:

> . . . the production of these advanced manufacturing goods (such as wearable tech, autonomous vehicles, biochips and biosensors, and new materials) are most likely to collocate with R&D facilities in high-income economies . . . This mirrors the manufacture of certain capital goods and advanced inputs (such as semiconductors, doped wafers for semiconductors, and fibreoptic cables), which stayed in high income economies during Industry 3.0. (Hallward-Driemeier and Nayyar, 2017: 93–94)

Furthermore, greater digitalisation through the IoT (Internet of Things), the report argues, may shorten value chains, further shifting production if it becomes more efficient, to rebundle activities in 'smart factories'. Smart factories use the IoT not just to automate production but also to communicate and share information. This allows reshoring of formerly labour-intensive manufacturing activities to high-income countries and closer to the final consumer. 3D printing is predicted to decrease the importance of scale because small and medium enterprises (SMEs) could access international designs and print locally. Shifts in consumer demand and the ability to customise outputs and thus shorten time to market will disrupt supply chains and change the nature, extent and location of employment. When factories are organised as networks of robots and cybernetic systems, less labour is needed, and the labour hired in the factory will be highly skilled, able to identify and solve problems and re-programme technology when necessary. Smart manufacturing thus requires territories where highly skilled labour is available and where infrastructure, particularly connection infrastructure, is sufficiently developed. Besides reshoring, another predicted trend in production reorganisation is company focus on high phases of the production process, namely pre- and post-manufacturing (Hallward-Driemeier and Nayyar, 2017: 93–96).

However, de-localisation may be constrained by the absence of skilled labour and inadequate protection of intellectual property. The 3D printing model effectively substitutes trade in services (through the payment of licence fees and royalties for designs) for trade in goods. Therefore, 3D printing may end up clustering around hub locations close to major markets.

Arguing that there is no inevitability to globalisation, Livesey (2018: 179) suggests that we are seeing early signs of deglobalisation for the making and supplying of physical products across a number of industries, creating problems for developing economies by exacerbating premature deindustrialisation. New production technologies are key to a new geography of making. Evidence for deglobalisation is taken to be the fact that, following the Global Financial Crisis (GFC), global trade is growing at a slower pace than global gross domestic product (GDP). Regionalisation rather than globalisation is likely to gather pace, owing to the pressures of new production technologies, automation, and the demands for speed and environmental constraints. Regionalisation is likely to deepen the path for localisation for some types of manufacturing, and thus a shortening of GVCs. As half to two-thirds of world trade happens within value chains, this has important implications:

> While developing economies may be shut out of manufacturing-led growth, there is more and more attention being paid to the possibility of the increases in manufacturing in leading economies like the USA. (Livesey, 2018: 185)

In 2019, Gary Gereffi, the leading theorist of GVCs, with two colleagues, sought to bring together an updated analysis of GVCs with an analysis of the implications of i4.0 (Brun et al., 2019). i4.0, they suggested, is changing what can be done by machines and what must be completed by humans, challenging the extensiveness of production in geographical space and the density of interactions between buyers and suppliers (Brun et al., 2019: 37). Technological change, it is argued, is creating a new form of multinational enterprises (MNEs; digital economy MNEs) which value non-physical assets more highly than physical assets. 'Lightness' among these firms not only has implications for regions, but well may be a harbinger for 'lightness' among all industries.

Following the GFC, Brun et al. (2019: 40–41) see four broad GVC dynamics occurring:

1. Rationalisation – in favour of fewer, more capable suppliers;
2. Regionalisation – this has two elements: first, firms in North America, Europe and Asia look for low-cost areas of production in their own regions; second, the growth of South-South trade, the fastest growing corridors of world trade;
3. Resiliency – important because of potential disruptive events;
4. Digitalisation – the use of advanced data analytical tools and physical technologies to improve the digital connectivity and technological capabilities of supply chains.

The overall vision, Brun et al. (2019: 47–49) contend, is to automate and integrate production lines and to design and produce collaboratively and virtually. Digitalisation is leading to three broad trends in value chains:

> (a) Extended disintermediation of supply chains allowing goods and service producers to produce and deliver their products to end users bypassing supply, distribution and sales networks
>
> (b) An increased role of services – revivification – which comes in three forms: unbundling capital equipment into services provided by external providers; unbundling manufacturing related activities into a service provided by external providers; the capture of production and user data into a value-added service
>
> (c) Capital substitution of labour due to automation. Investment in automation and robotics increases, the capital intensity of production rises, changing the type and amount of activities performed by human labour.

Gereffi, in a 2018 interview, argued that 3D printing in particular would be crucial, producing a potential manufacturing paradigm shift, which would facilitate the decentralisation of production. He concluded that industries can now be reorganised in ways where proximity to the consumer is going to be even more important than labour costs, which are falling throughout the chain as a result of automation (Brink, 2018). This development, according to an argument first advanced in 1992, shifts the 'smiling curve' of GVC production and value distribution, so called because high added values are located on both ends, the up- and down-streams, of an industrial segment chain. The middle stream industrial segment, in the middle of a 'smiling curve', for assembly works is said to have become the lowest value-added portion. From a GVC perspective, the 'smiling curve' depicts the ability of lead firms to unbundle and outsource low value adding initiatives and to generate or access technological breakthroughs (Rehnberg and Ponte, 2017: 58–61).

Contemporary growth of 3DP is explained not just by technological advances but also by two other paradigm shifts. First is an increased focus on services – servitisation – at each stage of production, from design through data-sharing to recycling. Second is digitisation of manufacturing processes, for example, through big data analytics, the IoT and data-sharing platforms. Rehnberg and Ponte (2017: 62) note the role of public policy discourse and funding in promoting the role of 3DP in high value-added manufacturing.

The impact of 3DP is likely to vary by industry. Take up industries are likely to see shorter value chains, decreasing production of and trade in intermediary parts, and more geographically dispersed industry structures. Thus, we can expect the emergence of denser networks of local producers, co-located with final users (Rehnberg and Ponte, 2017: 64). GVCs in industries such as aerospace, medical, dental, defence automotive and education are cited as leading these trends.

There are two possible scenarios for the 'smiling curve:

- A *complementarity scenario* – in GVCs where production volumes are higher and economies of scale important, the impact of 3DP will be limited to pre- and post-production. Existing structures and power relations will then be reinforced. Labour-intensive and low value-added processes will still be present in production, with 3DP deepening the smiling curve. Value added will move further away from production. The number of function and geographic and actor-size distribution do change dramatically
- A *substitution* scenario – in GVCs where production volumes are low and economies of scope more important, production materials can be processed through layering technology, and 3DP can produce significant transformation. The tendency is towards multipolar forms of governance, and expanded roles for 3DP lead firms in adopting CVCs. The relative weight of value added rises in production – and transforms the smile into a 'smirk' (Rehnberg and Ponte, 2017: 58–64).

In the second scenario, there is a more equal distribution of value added along the GVC. This has a significant impact on the geography of production, with a partial regionalisation and reshoring of production activities . There is also an impact on size of operations, with smaller and larger producers coexisting (Rehnberg and Ponte, 2017: 58–64).

Brun et al. (2019: 50) argue that the question currently unanswered is the degree to which the adoption of Industry 4.0 technologies will complement rather than substitute labour. Both are likely to occur simultaneously.

In an examination of the uptake of electric vehicles in the United Kingdom, Morgan (2020: 973) argues that the context and issues within which these developments are taking place are not widely understood and that problems are understated. In what follows we would suggest that the same criticism applies to 3D printing and i4.0 and its coverage in Australia. Morgan concludes that the result is a 'technocratic' form of analysis. The literature we have examined tends towards heroic, and technocratic, assumptions regarding the impact of 3D printing without any detailed analysis of what this new technology actually comprises. Despite these problems, the Australian Government and the Advanced Manufacturing Growth Centre (AMGC) are enthusiastic proponents.

Advanced manufacturing in Australia

In Australia, the AMGC (n.d.a) has bought in fully and uncritically to the new narrative:

> Digital innovations such as 3D printing, which allows goods to be produced anywhere, at anytime, overlay the new manufacturing value chain and are accelerating the reinvention of the assembly line. Industry 4.0 technologies denote a broader paradigm shift in which intelligence and machine learning are embedded across the entire manufacturing cycle. (p. 8)

In a submission to the Australian Government's Department of Industry, Innovation and Science, the AMGC argued that for Australian manufacturers, building relationships with global systems integrators or primes was worth the costs of investing in new equipment or becoming compatible with the latter's business software (including complying with cybersecurity requirements) because in so doing the company was 'pulled up' or 'dragged on the journey'. Furthermore (AMGC, n.d.b),

> By embracing Industry 4.0, Australia can even begin to 'reshore' some production from countries with low labour and electricity costs, such as China. This will help bring back jobs to regional areas . . . In particular, capabilities such as 3D printing . . . have the potential to help Australian manufacturers meet demand for highly customised products and materials that can be quickly replicated anywhere in the world. According to one local manufacturing expert: '*Whereas previously you may have been a manufacturer of toys, bikes or weapons, 3D printing capabilities mean that on Monday you print toys, on Tuesdays, it's bikes and on Wednesday its weapons*'. (p. 10)

3D printing is apparently going to help relocate and thus aid the restoration of Australian manufacturing.

And then came COVID-19

The advent of COVID-19 had some immediate and far-reaching consequences. For example, the resulting almost complete shutdown of China had a dramatic effect, as

Chowdhury (2020) pointed out: 94% of the Fortune 1000 are seeing coronavirus supply chain disruptions. Across the world, the fragility of Just-In-Time driven supply chains has been vividly exposed. The impact on Australia was significant: ‘Besides the well-publicised impact on airlines, universities and tourism, Australian construction companies are warning clients of upcoming project delays as a result of forecast disruptions in material sourced from China’ (Hopkins, 2020).

Writing in *The Guardian*, Roubini (2020) gave the following as one of the 10 reasons that a Greater Recession was inevitable:

> To guard against future supply shocks, companies in advanced economies will reshore production from low-cost regions to higher-cost domestic markets, this trend will accelerate the pace of automation, putting downward pressure on wages and further fanning the flames of populism, nationalism and xenophobia.

Media commentary, for example, in *The Australian Financial Review*, has advocated more resilient supply chains insulated from the prospect of global disruption and a rebuilding of domestic manufacturing capacity for critical goods:

> The health and well being of Australians is a national security-resilience issue and one that has to be assessed for risks and vulnerabilities just like every other aspect of national security form energy to the economy to the environment to the military. (Coorey, 2020)

Andrew Liveris, a special advisor to the Australian National COVID-19 Commission and former CEO of Dow Chemicals, also bought into the new conventional wisdom (Stott and Aedy, 2020). He argued that the domestic shortage of all personal protective equipment (PPE) items had brought Australian manufacturing, or the lack of it, to national attention. Pointing to Australia’s current standing of 87th in the Harvard Growth Labs Economic Complexity Index, he suggested that the country needed onshore access to the basics of healthcare, energy, defence, technology, food and water. He was quoted as arguing that ‘we are connected to the world through technology these days, and that means we can have new opportunities to scale, in areas we could not scale before’. Lightweight materials, advanced sensors and 3D printing would help produce the technologies and goods needed for the 21st century. The market itself would not be capable of driving this innovation; top down control would be needed to balance bottom-up innovation. Workers in this new world would have to be ‘new collar’, that is, very proficient with technology and the human–machine interface (Stott and Aedy, 2020).

A different view

Having laid out what, in some quarters, is being viewed as a new orthodoxy, I will now paint a different picture, starting out with a brief critique of i4.0. We then move on to evaluate literature which has taken a more critical view of the prospects of urbanisation, innovation, reshoring and clustering.

i4.0 has not gone unquestioned (Rainnie and Dean, 2020). Pfeiffer (2017a) has warned that the technologically deterministic view of i4.0 and its technological marvels threaten a ‘digital despotism’ that will make human workers subservient to integrated digital production systems that monopolise decision-making. It is in this vein that Reischauer (2018) has interpreted Industry 4.0 as a policy driven discourse intended to embed a digitally driven innovation system in manufacturing production, fulfilling capital's essential drive to expand in the form of a digitally-driven regime of accumulation. This is what Morgan (2019: 14) defines as a 'quasi-determinism' where 'anxiety combined with passivity and complacency are being produced'. Pfeiffer (2017b) has also interpreted i4.0 as a marketing exercise that provides an imaginary vision of a future in which none of the sociological implications have been given much detail. Fuchs (2018) echoes this sentiment, arguing that Industry 4.0 acts as a 'capitalist panacea' to economic and social problems that ignore the existing social and economic inequalities being created by the 'disruptive' nature of digital capitalism.

While attention was focussed on i4.0, a parallel and crucial debate was taking place over the emergence to (a supposed) predominance of Platform Capitalism, which had a geography associated with it that bore little resemblance to that of i4.0. However, we first look at the dynamics of the growth of megacities and the emerging geographies of innovation associated with this phenomenon.

Extreme cities

For Kanai and Schindler (2018: 325), under the conditions of globalisation, economic activity is clustering within massive territorial formations that incorporate and functionally integrate multiple city regions. However, there is a downside to the emergence of a distinctive new urban form: the polynucleated, densely networked, information-intensive and increasingly globalised city regions. It is necessary to take stock of developments:

> . . . such as creation of acute social hierarchies and the heightening of power asymmetries . . . also the intensification of geographically uneven development in a world system of increasingly integrated but also differentiated economic territories. (Kanai and Schindler, 2018: 323)

Dawson (2019: 6) argues that this heralds the era of 'extreme cities'. The extreme city 'refers to an urban space of stark economic inequality, the defining urban characteristic of our time, and one of the greatest threats to the sustainability of urban existence'. The city is where capitalism's central contradictions play out. In the world of 'smart cities', an optimistic view sees these forms as breeding grounds for the new entrepreneurialism, wherein smart technologically enhanced forms of urbanism will herald a new era of green urban growth – a new era of efficiency and resilience based on compact green cities However, resilience will be necessary to cope with the downside:

> Resilience is an opportune lens for elites to adopt in coping with the extreme city. Resilience has become the dominant jargon for addressing the manifold crises of the extreme city without addressing the problems that give rise to these crises. The power of the term resilience is the sheen of hope it offers. (Dawson, 2019: 170)

The importance of the extreme city phenomenon is that it links globalisation, multinational enterprises, extended urbanisation and innovation.

Geographies of innovation and urbanisation

For Crescenzi et al. (2020: 3), the global spread of technology development is increasingly associated with stronger metropolitan-scale concentration:

> If there are images that can capture this emerging geography it is that of a globalized hub-to-hub (or hotspot to hotspot) system, or concentrated dispersion.

The latest wave (3rd or 4th Industrial Revolution?) followed the second which had focussed on the high-income club of the world in North America and regions of Europe. It had produced a tendency towards inter-regional income convergence in the middle decades of the 20th century. The new revolution produced a spread of development at a global scale to include a rapidly developing set of Asian economies, particularly China. However, with the exception of China, the structural hierarchy of global per capita incomes did not converge, because high-income countries had succeeded in reproducing their position in the global hierarchy through sustained innovation and productivity improvements.

Despite the spread of development, many countries witnessed increasing inter-regional polarisation of incomes and opportunity, manifesting in the rise of superstar cities and left behind regions (Crescenzi et al., 2020: 6). In contrast to the middle years of the 20th century, we are witnessing a 'great inversion'. The concentration of technology production in sub-national metropolitan hotspots mirrors the geography of per capita income and the increasing concentration of the skilled in hotspots. The hubs or hotspots stand in stark contrast to those areas and regions left behind (for a critical discussion of emerging patterns of global inequality, see Hickel, 2017).

For Brenner (2019: 23), as nodes of accumulation, cities are no longer enclosed within relatively autocentric, national economies, but have been embedded more directly within transnational urban hierarchies, inter-urban networks and circuits of capital. The implications for urban governance are important:

> Post Keynesian urban governance are likewise being comprehensively rewoven: they are turned inside out insofar as state institutions, at various spatial scales, attempt more directly to enhance the global structural competitiveness of strategic subnational, spaces such as cities and regions; and they are simultaneously turned outside in insofar as supranational governance agencies, multinational regulatory alliances and transnational corporate and financial organisations now come to play more active, multifaceted roles in the reorganization of each states national territorial economy, often with profound ramifications for the fortunes of cities and regions.

Post Keynesian rescaling strategies follow on from this process of being turned simultaneously outside-in and inside-out:

1. Promote concentration of high technology industry specialisations in national territory's most globally networked spaces;
2. Encourage increasingly divergent place specific forms of economic governance, welfare provision and territorial administration;

3. Institutionalising competitive relations, whether for public subsidies or private investments among major sub-national administrative units.

Thus, the declared goal is no longer to alleviate uneven development but to intensify it through policies designed to strengthen unique space-specific assets and infrastructural equipment of transnationally networked urban regions.

However, crucially for our argument, there is little systematic evidence of any general success of policies trying to create new local clusters. Firms form ecosystems that are not easily transplantable or reproducible. For Brenner (2019), although information communication and technology (ICT)-based forms of urban development may successfully unleash short- or medium-term bursts of economic growth within a small group of privileged ‘first mover’ local and regional economies, the conditions underlying these putative paradigms are extremely difficult, if not impossible, to replicate or generalise elsewhere:

> The international dispersion of innovation follows patterns of the global division of labour, as innovation activities pushing the technology frontier takes place in (relatively few) established centres of excellence, whereas more routinized research activities take place in emerging economies. MNEs can be considered key agents of dispersion, but they also do from a position of high levels of embeddedness in their national economies, and usually within specific regions within their countries of origin. (Crescenzi et al., 2020: 12)

While innovative activity is spreading globally, there are strong agglomeration forces that result in clustering of innovators and innovative firms and institutions, but this is very different from the i4.0/3D printing dream outlined in the first part of this article. This spatial concentration is mirrored in the concentration of university graduates and STEM workers as well as international and inter-regional migration of graduates in general, and innovators in particular, towards innovative regions. Localised networks are among the centripetal forces attracting agents to dense labour markets:

> While high skilled jobs create many low skilled jobs in the home market . . . inflows of high earners combined with inelastic housing supply often result in inequality and falling disposable income for low income households. Ultimately, this leads to increased . . . sorting by skill groups into innovative, high-earning areas., excluding the low-skilled from the opportunities and amenities of living and working in an innovative environment. (Crescenzi et al., 2020: 20)

Again, for Brenner (2019), owing to their relatively circumscribed sectoral, labour market and spatial impacts, urban development policies oriented towards new economy industries tend to intensify uneven development, socio-spatial exclusion, and territorial disparities across spatial scales.

The problem does not get any less acute if we examine the implications of AI and Platform Capitalism.

Geography of AI and Platform Capitalism

Clifton et al. (2020) argue that the geography of technology development and adoption appears to be following mostly tried and true paths based on existing sites of human capital formation and long-standing industrial concentrations. However, technological diffusion of AI or other technologies is not always straightforward and can be complicated by regional or national working practices.

Clifton et al. (2020) also draw a distinction between the *development* and the *adoption* if AI. The *development* of AI is likely to reinforce the economic power of existing agglomerations. Growth is most likely to occur in ready-made clusters of similar activities, and thus do little to improve the problems of uneven development. Initial endowments are therefore critical determinants of an area's potential to benefit from developments in technology, leaving lagging regions at a distinct disadvantage. The *adoption* of AI is also likely to be uneven and strongly tied to existing industrial strengths and weaknesses. Poorer regional economies in peripheral regions are most likely to experience job displacement from automation.

Langley and Leyshon (2017) see platforms as being defined by a particular combination of socio-technical and capitalist business practices, with the generative forces of the platforms turning on practices of intermediation and processes of capitalisation. The digital economy is characterised by a tension between 'distributed capitalism' in which infrastructure is distributed, and 'netarchical capitalism' where infrastructure is in the hands of centralised privately owned platforms. This, it is claimed, solves the coordination problems in market exchange by extending the distance-shrinking networking capacities of the Internet. Platform intermediation combines three distinct operational layers (Langley and Leyshon, 2017: 17). First, a network or community layer consists of platform participants; second, an infrastructure layer is made up of software tools, rules and services; and third, a data layer allows platforms to attempt to match supply with demand. The platform then mobilises the infrastructures of participation that are immanent to the new digital economic circulation. Platforms then are at once, techno-cultural constructs and socioeconomic structures, and, furthermore, standardise the circulations in which they specialise.

For Kenney and Zysman (2020), the apex platform giants have increasingly become the central firms, reshaping the geography of economic activity. Concentration in the digital platforms has two components and one result. The first component is that in each sector, one or two forms control most of the market and the dominant players are constantly expanding into adjacent markets. The second component is that, in the United States, the HQs of the platform giants are overwhelmingly concentrated in the San Francisco Bay area and Seattle. Therefore, the logic of the platform economy is increasingly dictated by the business imperatives and ideology of the West Coast and that an increasing share of global wealth is rerouted through these two locations.

In geographical terms, the entrepreneurial and managerial core of these firms is concentrated in the home bases, augmented by a huge number of largely invisible contract employees, often employed by labour-contracting firms. There is, therefore, a vastly expanded market in terms of geographic reach which allows far more people to transact. The platforms have also been introduced for service provision, both in person and remotely (Kenney and Zysman, 2020). The conclusion is that, at a global scale, the power to extract value is highly concentrated in a few firms located on the US West Coast. Most businesses are dependent on platforms and become consumers or merchants transacting on and taxed by the platform. Crucially, the platforms are re-routing commerce in ways that centralise power while decentralising the ability to participate in the economy.

Platforms, it is argued, manifest four distinct features in this regime:

1. A business model is adopted in which firms capture profits through digital intermediation, thus avoiding the encumbrances that ownership of fixed capital or direct employment of labour entail
2. The employment relationship is transformed from the closed model that hierarchies have historically employed, involving detailed control of employment and work. Platforms typically relinquish control, offering an 'open' employment relationship
3. Platforms have relinquished hierarchical controls of systems to ensure worker compliance, substituting new and more distributed mechanisms to govern the performance of tasks. Reliance is placed on the disciplinary effects of the market rather than high levels of centralised management control
4. Capitalism historically found it necessary to concentrate labour at the point of production. With the advent of cloud-based digital intermediaries, this trend is reversed. Deploying labour now effectively requires that workers be spatially dispersed (Vallas and Schor, 2020: 16.10–12).

There are obviously issues regarding the nature, extent and location of work here. We now turn to the question of re- and nearshoring.

Re- and nearshoring

Florian Butollo (2020) takes a critical look at the supposed reshoring dynamics in the new economy. He points out that the much-vaunted Adidas speed factory which apparently came 'home' to Ansbach rapidly shut down and instead the Speedfactory technologies were used in Asia based suppliers. New technologies may result in reshoring but also in new ways to fragment and globally distribute distinct tasks in GVCs.

Echoing our earlier criticisms of i4.0, Butollo suggests that reshoring is a narrative that claims to be a disruptive production model, one about potential developments. It is, however, technocentric (Morgan, 2020) and bears more than a passing resemblance to Lean Production. Furthermore, its claims for a drive to reshoring, though not without foundation, have a number of problems. First is the problem that the extent of automation of production and employment tends to be overstated. The theoretical possibility of automation is never matched by the complexity of reality. This is particularly true in the Australian case, with the Australian Institute (Stanford, 2020) arguing that 'The Robots are NOT coming'. Second is the usually mistaken assumption that the effects of automation will affect industries in high-wage countries. The effect of catch-up automation could as well serve to lower unit costs of production in emerging economies, if productivity enhancing technology is employed. Foxconn in China is engaged in massive investment to automate, radically reducing its workforce. Third, and following on from the second argument, a similar process could lead to nearshoring of production in adjacent or proximate low(er) wage economies.

As Butollo (2002: 7) concludes, if nearshoring prevails, the implications for workers in advanced industrial economies are very different from the positive scenario envisaged in the reshoring narrative. Butollo (2020) points out that i4.0 proposes a form of deglobalisation-driven 3D utopia whereby customers order their personalised item which is then produced in a nearby production facility to ensure instant delivery. Again, following in the footsteps of post Fordism, clusters of SMEs prove to be innovative and adaptable, perfectly suited to the new world (for a critique of the role of SMEs in late capitalism, see Barrett and Rainnie, 2002; Rainnie et al., 2013). The dream is reinforced by the idea of the 'smart factory' wherein '[s]uch factories are projected to manufacture products according to customers' needs by quickly adapting manufacturing through flexible automation and comprehensive digital monitoring and connection of processes based on IoT technologies. This is very similar to lean techniques of supply chain management which ensure just-in-time and just-in-sequence delivery of components' (Butollo, 2020: 9).

Crucially Butollo argues that what he calls Logistics 4.0 offsets the advantages of geographical proximity. By Logistics i4.0 Butollo means an interlocking of processes, objects and supply chain actors through IoT technologies that provide real-time information regarding the location and condition of objects that can be used to streamline delivery processes. The generated data can also be used to run algorithms to detect patterns, which in turn can improve predictability and efficiency of logistics processes.

What is important is the merger between logistics and manufacturing in large suppliers and the e-commerce logistics nexus. The first element focusses on the concentration on fewer larger suppliers who take on supply chain management and logistics responsibilities in modularised supply chains. Production facilities do not need to be located close to end markets since the combination of digital data transfer, downstream product customisation and sophisticated logistics ensure the fast delivery of products although the bulk of hardware production was located overseas. The e-commerce logistics nexus allows for rapid response to specified market demand even across large geographical distances:

> Logistics 4.0 . . . thus, allows for bridging greater geographic distance while still meeting the requirement of fast market response. On-demand production systems therefore do not necessarily require a regional integration of producers and target markets . . . (Butollo, 2020: 12)

Modular product architectures further enhance the ability to fragment the value chain and locate activities at a geographic distance. The electronics industry has taken modularisation to great heights, setting up a global industry around hubs for key inputs. Sturgeon (2019) suggests that there are two reasons why lead firms can fragment value chains through new technologies. First, the ability to codify and transfer information is enhanced by computerisation, which drives standardisation and modularisation. Second, the rise to pre-eminence of platforms reinforces this process. Platforms therefore open up the ability to create complex products that consist of a combination of intangible software layers and tangible hardware components, thus allowing for a geographically segmented value chain.

Butollo concludes (2020: 14) that the relationship between digitalisation and geographies of production reveals contradictory tendencies. New digital technologies do not create new value chain arrangements as such but are integrated into existing structures that depend on a variety of factors:

> *Automation* – is unlikely to trigger a general trend towards reshoring. If anything nearshoring, rather than reshoring looks more likely.
>
> *On-demand production and logistics* – the e-commerce / logistics nexus constitutes a countervailing factor to the logic of regional integration of producers and target markets. Global sourcing is still feasible in industries where transport costs are low and the modularisation of product architectures can be easily achieved.
>
> *Modularisation and fragmentation* – the codification of production-related information and the ability to digitally transfer this information expand the scope for modularisation of product architectures and modes of supply chain governance which can tolerate geographical distance.

The picture that emerges is complex and far removed from the simple (simplistic?) cluster formations beloved of the i4.0/3DP conventional wisdom.

Conclusion

As we have seen, a new conventional wisdom suggests that 3D printing is going to help motor a revival of clustered firms producing a new geography of reshored manufacturing industry. This process of deglobalisation is going to have implications for the nature and location of employment into the future. This prediction has been widely, and usually uncritically, accepted, including in Australia. However, if we draw on analysis of urbanisation and the emergence of mega or extreme cities a different picture emerges. The alternative view is reinforced if we examine the emerging geography of Platform Capitalism. Power remains highly concentrated, largely metropolitan based, and re- or nearshoring appears to be overplayed. On this reading, and taken together with our earlier analysis, the emergence of new clusters in localities is not impossible. However, outside the already existing hubs and hotspots, it is unlikely. Even if it does occur, it will tend to be fleeting.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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