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Smart rural futures: Will rural areas be left behind in the 4th industrial revolution?

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ABSTRACT

The 4th Industrial Revolution (4IR) is the term given to encompass a range of technological developments that many argue will fundamentally change society, much in the same way that electricity and digital technology did during previous industrial revolutions. This paper argues that current debates around 4IR are centred on the urban core, with rural areas being relegated to the periphery and the remainder. The paper therefore examines these technologies from a rural perspective and considers what impact they could have in rural areas, both positive and negative. The analysis shows that the impacts of 4IR technologies could be just as important in rural as in urban places. Drawing on extant theories of rural development, the paper examines the physical and cultural barriers facing rural areas when attempting to engage with 4IR. The paper concludes by proposing that rural theorists engage with smart urban theoretical debates. New research should seek to understand the multi-faceted aspects of 4IR in rural regions, and to support the transition to smart rural futures.

1. Introduction

In October 1984 Howard Newby presented a paper entitled “Rural Communities and New Technology” at a Seminar on “Future Issues in Rural Development” in Aberdeen (Newby, 1984). 1984 was the dawn of the age of personal computers and digital data storage. Schools had just been given the BBC Micro-computer to stimulate interest in this digital revolution. Somewhat optimistically Newby hoped that “for the first time since the Industrial Revolution rural areas may participate in a technological breakthrough on an equal footing with urban centres.” (Newby, 1984 p 19). Newby, in common with a number of other commentators (e.g. Cairncross, 1997), predicted this technological revolution would mean that rural areas would no longer suffer from issues of peripherality and a lack of connectivity. As we now know, this was not the case. Rural areas remain distant, both physically and technologically, from urban centres. One of the most enduring debates regarding rural development and technology concerns broadband connectivity (c. f. Galloway, 2007; CRC, 2009; Talbot, 2011; Townsend et al., 2013; Salemink et al., 2017; & Pant and Odame, 2017). That Newby’s vision for rural areas was not realised is arguably a function of both technical and socio-economic barriers. The market led roll-out of broadband and the lack of a critical mass of consumers in rural areas, as well as logistical

challenges with infrastructure resulting from remoteness and topography have prevented comprehensive coverage. Recent figures show rural areas, and particularly remote rural areas, are significantly lagging their urban counterparts in terms of speed of connectivity (DEFRA, 2018). Coupled with this sparsity, rural areas are characterised by ageing populations which tend to be late adopters of new technologies (OFCOM, 2018). There is also a popular image of rural areas as a refuge from technology. For example, an online advert for Spotify (the music streaming service) portrays a character in a mild state of panic as they realise they may not be able to stream their music whilst on a weekend break in the countryside. Whilst it can be true that some people seek a particular lifestyle in rural living which includes going “offline” and disconnecting from the digital world, for the most part households and businesses require adequate connectivity in order to carry out their day to day tasks and business activities.

As argued by academics for more than a decade (Hannsen et al., 2007; Townsend et al., 2013, 2016; Salemink et al., 2017), availability of universal high-speed broadband is undoubtedly critical to rural development. Furthermore, this issue has not yet been adequately solved in most countries, with a few exceptions, including South Korea and some Nordic countries. Nonetheless, a rapidly accelerating digital society has resulted in the wider technological debate moving on to

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encompass the technological advances that are being used across industries globally at this time. Therefore, this paper seeks to progress the academic debate beyond a focus on uneven broadband connectivity. The 4th Industrial Revolution (4IR) is an umbrella term for a range of technologies that are expected to transform the way people live, work and play (Schwab, 2017). Technologies falling within the ambit of 4IR include the Internet of Things (IoT), robotics, artificial intelligence (AI), autonomous vehicles, and 3D printing. Whilst each of these technologies is powerful in its own right, when combined they are expected to bring significant changes in the way people live, work and play (Graham, 2016). It is this cumulative effect which distinguishes 4IR from the preceding 3rd, digital, industrial revolution (Corfe, 2018).

Whilst Newby was wrong about the rural's participation in the first wave of technological change, he was correct about the need to "avoid a narrow technological determinism – the view that technological invention automatically and inevitably results in a given set of social change" (Newby, 1984: p1). This has been echoed more recently by writers such as Feenberg (2002) who takes issue with the idea that "technology, as pure instrumentality, is indifferent to the variety of ends it can be employed to achieve." (2002: p5) Both Newby and Feenberg argue that technology is socially constructed and its impact on society is very much controlled by, and in turn, has a degree of control over societal forces. This means it is vitally important to fully understand the effects of technology and how it is integrated into social systems and the role it plays in mediating the sociotechnical systems it thus creates. This is reflected in work on "Responsible Research and Innovation" (or RRI). RRI is a way of doing and thinking about research and innovation which acknowledges that the design of new technologies creates power imbalances resulting in uneven benefits and disadvantages within different stakeholder groups. RRI calls for designers and innovators to consciously examine these issues in the first stages of development by asking "what these technologies ought to do, and for whom" (Bronson, 2019). RRI approaches are underpinning new research projects on digitalisation and innovation, particularly research funded by the European Commission such as the Horizon 2020 project "DESIRA" ("Digitalisation: Economic and Social Impacts in Rural Areas"¹).

This paper argues that rural areas risk being left even further behind as the next stage of technological innovation begins to have a significant societal impact. It further argues that many new technologies are framed within an urban and particularly neo-liberal approach to development (Kitchin et al., 2018), an approach which, when considered through an RRI framework, can arguably further marginalise rural areas. What is required, therefore, is for *responsible rural research and innovation* (which we might term "RRRI") which engages with the structural problems facing those rural communities and considers how technologies may be able to address these.

In the next section of the paper the concept of 4IR and its relationship to concepts such as smart cities and digitalisation is examined. These concepts are then related to rural development using three technologies as examples: Connected and Autonomous Vehicles (CAV), Smart Grids and the Internet of Things (IoT). The paper then moves on to consider the theoretical frameworks that underpin research in this domain. This draws on the theoretical frameworks used to investigate and critique smart city discourses but also examines existing rural research paradigms to consider how they can be used to understand the challenges and opportunities presented by 4IR and associated new technologies in rural areas.

In the final section the paper considers some of the pre-existing academic rural discourses and how they might be applied to the issue of next generation technologies and their effect on rural areas. The paper concludes by proposing that rural-specific challenges should be researched and addressed, and in turn inform critical societal and political debate around 4IR and smart development.

2. The 4th industrial revolution, smart cities and digitalisation

As highlighted above, the 4th Industrial Revolution (4IR) is an umbrella term for a series of technological developments that are characterised in that they 'leverage the pervasive power of digitization and information technology' (Schwab, 2016: 19) and by the integration of physical, technological and biological systems (*ibid.*). Data and the flow of knowledge are the raw material of the age coupled with a speeding up of the development cycle. New technologies or services emerge and become ubiquitous over a much shorter timeframe than in the previous industrial ages. Companies like Uber, AirB&B and Amazon have become the dominant players in their respective industries within a very short time frame (Parker et al., 2016). This speed of development causes problems for regulators, politicians and planners who often struggle to adapt institutional and legal frameworks that take years, if not decades, to change. It also causes significant issues for society and the communities affected by this disruptive change. Amazon for example has had a significant impact on traditional bricks and mortar shops (Thomas, 2018), while AirB&B has had significant effects on house prices and availability in a number of urban and rural tourist hot spots (Ioannides et al., 2018), often pricing people out of their local market. What this shows is something also identified in Howard Newby's 1984 paper, that "the pace and direction of change are as much a product of the social and cultural context within which technological innovation occurs as of mere invention and availability." (Newby, 1984, p1).

It could be argued that many of the technologies encompassed within the term 4IR have been developed to tackle the specific challenges presented by the extraordinary growth of cities, and in particular the issue of density and resource efficiency (Kitchin, 2015). It is a common trope in the introduction to many a smart city text that 50% of the world's population now reside in cities. This expansion of cities creates many practical governance, security and resource allocation problems which are being faced by city administrations with dwindling budgets. Smart technology is touted as a way to square this circle, offering better city management at the same time as reducing the cost to the administration. This discourse of smart technology as a solution to 21st century city problems acts to marginalise rural areas which do not suffer from these specific urban problems but instead face their own distinct challenges. Following the well-developed discourse of a 'rural idyll' (Short, 1991) rural areas are often seen as the antidote to technology, the place to get away from the always-connected world.

It is not just the individual technologies that are making an impact. Many of the technologies that have been dubbed 'smart' seek to combine a number of technologies to attempt to understand the city as a system of systems (Marvin and Luque-Ayala, 2017). A good example of this can be found in the attempt to bring digital technology to bear on the problem of policing the city. Many of the smart policing solutions sold to cities involve IoT based mass surveillance which generates huge amounts of data which in turn is processed using Artificial Intelligence (AI) and sophisticated algorithms (O'Neill, 2016). These are promoted as being both more resource efficient than traditional policing methods and less biased than humans (*ibid.*). The idea that technology is unbiased is common discourse in smart city domains. This is based on the idea that if enough data can be captured and sufficient computing power can be brought to bear on that data, it will be possible to understand and manage any complex system without any *a priori* theoretical framework (Batty, 2013). This is very much in accord with the 'technological determinism' Newby warned against in his 1984 paper. Similarly, there is now a growing critique of this neutral view of technology, particularly the algorithms used to inform public institutional decision making. O'Neil (2016) and Amore and Piotuch (2015) make the point that these algorithms contain many human flaws and are not as unbiased as they first appear. For example, certain locations, and thus certain sections of society, are subjected to much higher levels of surveillance by smart technologies than others (Graham and Marvin, 2001). Whilst in theory, the data analysis may be done through unbiased algorithmic methods

¹ <http://desira2020.eu/>.

this may not solve the problem as there are often flaws in the way the data sampling takes place (O’Neil, 2016). When considered through the lens of RRI, in practice these smart technologies tend to reflect or even amplify unjust societal structures. Finally, there are issues of justice and legitimacy associated with democratic institutions such as municipalities relying on smart technologies where the decision-making processes are hidden within a black box protected by commercial confidentiality (Kitchin et al., 2018).

Whilst there are justifiable critiques of the way in which the new technology is being deployed, there is no doubt it can have some positive benefits for society. The issue debated in this paper is what role the rural can and should play in this process. Although rural development is not central in the 4IR discourse, there are initiatives centred on the transformational potential of digitalisation for rural regions. For example, within the work of the European Commission’s European Network for Rural Development (ENRD), “Smart Villages” has been identified as an important theme within the network’s work on “Smart and Competitive Rural Areas”.² Work on Smart Villages concerns the role of innovation for the resilience of rural places and considers the relevance of both technological and social innovation for rural development. The development of rural Living Labs (Living Labs are “open-innovation ecosystems”³ aimed at boosting innovation within regions and sectors) is another example of work putting technological innovation at the forefront for rural development. Within the UK, a number of initiatives are aimed at harnessing the power of technology for rural places.

However, for those initiatives engaging directly with technologies found within the 4IR discourse, including those that we focus on in this paper (Connected Autonomous Vehicles, Internet of Things and Smart Grids), the main rural focus is Agriculture (see for example the four Agri-Tech centres, supported by UK Government to deliver £90million worth of research and innovation which builds resilience and growth in the UK Agrifood sector⁴). This mirrors the literature, which has considered the more high-tech digital advancements mostly in relation to Agriculture, thus marginalising rural people and places in the narrative (Wolski, 2019). The impacts of 4IR on wider rural development (for example at community level, and in terms of small-scale rural economies) are not addressed to the same level – either in policy and Government-led initiatives, or in the literature. Wider (digital) rural development remains the domain of discourse on digital literacy, broadband connectivity, and other technical aspects of the digital divide (Young, 2019).

As argued above, many of the technologies cited in 4IR discourse have been developed to tackle issues faced by cities. This paper considers how these technologies might impact on rural society. In many cases the problems facing rural areas are the opposite of those facing cities: low density of population making it difficult and expensive to provide public services; peripherality and poor connectivity making it harder to participate in certain social and economic activities; and finally, demographic issues with an older population and associated issues, for example regarding technology adoption. Clearly, technologies designed with an urban bias will not be fit to support the development of rural communities facing such challenges. Is it possible that such developments could even marginalise rural areas further? In the next section of the paper, three new technologies and their potential impact on the structural issues facing rural areas will be considered.

3. The 4th industrial revolution and rural development

Whilst the concept of 4IR spans numerous technologies, this paper will consider three: Connected and Autonomous Vehicles; the Internet of Things; and Smart Grids. Each of these technologies is relatively well

advanced and has been studied in a smart cities context for a number of years. The impact of these technologies on rural economies and communities is less understood. As discussed above, much of the previous work on 4IR technologies in a rural context concerns Agriculture; whilst the authors acknowledge the valuable body of work that has been developed in this field, this paper will not address this area in much detail (for an excellent overview of the work being done in this field see editorial by Klerkx et al., 2019, and the corresponding Special Issue). Instead, this paper focuses on the gap in considering 4IR in relation to wider rural development and society.

For each of the three technologies an overview of the technical aspects of the technology will be given and the main debates within the literature for the technology will be considered. Finally, each technology will be considered in a rural development context. This will examine the specific issues facing rural areas when seeking to develop such technology and the wider relationships between the cities and rural areas as the technology develops and matures.

3.1. Connected and Autonomous Vehicles (CAV)

The UK Department for Transport’s definition of an Autonomous Vehicle is:

“This means a vehicle in which a driver is not necessary. The vehicle is designed to be capable of safely completing journeys without the need for a driver in all traffic, road and weather conditions that can be managed by a competent human driver” (DfT, 2015a).

The connected element of the definition relates to the ability of the Autonomous Vehicle to connect digitally to a range of external systems, for example highways infrastructure, other CAVs or other road users. CAVs are intended to overcome a number of issues associated with current private transport systems: congestion, safety, pollution and land use (DfT, 2015b). Many bold claims have been made on the benefits of CAVs - for example they will eliminate over 90% of accidents (Gao et al., 2014) or significantly reduce congestion and pollution (Walldrop, 2015). Most new cars produced today contain elements of automation such as cruise control, automatic braking and even self-parking. It is anticipated that there will be a gradual transition to fully automated vehicles with an intermediate stage where cars can be driven in either autonomous or manual mode depending on the circumstances (DfT, 2015b) as well as CAVs being limited to certain roads, i.e. motorways (Stone et al., 2018). The shift to a world dominated by CAVs raises several connected socio-technical issues as well as numerous moral ones (Bonneton et al., 2016). One of the biggest social benefits of CAVs is their potential to offer all segments of the population the same level of mobility, regardless of issues relating to age, health and physical mobility. For rural areas this would have significant benefits for the elderly and physically impaired groups which fair particularly badly in terms of rural mobility (Harris, 2018). At the other end of the age spectrum, CAVs could offer young people greater independence and access to leisure and educational opportunities that they often miss out on or, when older, must move away from the rural area to access. CAVs will not just carry people but also goods. Internet shopping and home delivery have already had a significant impact on accessible rural areas. Deliveries by CAVs have the potential to widen this benefit to all rural areas. However, this is not a straightforward benefit to rural areas, as it increases competitive pressures on indigenous retailers (see also Cumming and Johan, 2010 for the impact of Internet shopping on rural economies).

There are two technical issues that are relevant to rural areas: the need for accurate and detailed maps of the areas in which CAVs will operate (OS, 2018) and the need for ultra-reliable low latency 5G connectivity (GSMA, 2018). Mapping any rural area in such detail and creating a network to support 5G connectivity is costly and requires the promise of significant return on investment for those undertaking such an exercise. Cities are the obvious place offering such a return on investment particularly in the early stages of development where costs are

² https://enrd.ec.europa.eu/enrd-thematic-work/smart-and-competitive-rural-areas/smart-villages_en.

³ <https://cordis.europa.eu/project/id/773757>.

⁴ <https://www.agritechcentres.com/>.

highest (Salemink et al., 2017). In fact, this familiar story is a significant factor in the typically slower-than-urban broadband speeds experienced in rural areas – lower populations (and hence return on investments) coupled with remote and challenging geographies mean that rural and remote rural regions have always been less attractive targets for Internet Service Providers (Townsend et al., 2015; Salemink et al., 2017). The lack of suitable digital maps and rural 5G connectivity will mean availability of CAVs in rural areas or even the ability of urban CAVs to travel to rural areas is likely to be delayed and lag significantly behind urban areas. CAVs are therefore not likely to be of benefit to rural regions for some time, with the exception of work being done in the AgriFood sector to develop driverless tractors for future food production (for example Hands Free Hectare – see Spencer, 2018).

This has the potential to exacerbate the divisions between urban and rural areas, particularly during the transition phase in the adoption of CAVs. The business models being developed to push forward the first wave of CAVs are built around proprietary mapping and technology (e.g. Topham, 2018). Comparable with an RRI ethos, an alternative to a closed proprietary driven model for technology development is one which develops ‘digital commons’ (Teli et al., 2015), or open innovation models of development (Calzada and Cowie, 2017). An open model of development based on an active neutral host infrastructure (Weston, 2018) would allow rural areas to develop the technological infrastructure required to allow CAV operators to include rural communities in their services. The difficulty with this model of development is the issue of capacity in rural areas. As has been found with fibre broadband, capacity in rural areas to undertake the development of such infrastructure is extremely limited and very patchy (CRC, 2009; Townsend et al., 2013). To have any chance of becoming a universal service, CAVs and the required low latency 5G will require the intervention of government at a national and perhaps regional level.

3.2. Internet of Things (IoT)

The IoT is the term given for a network of physical objects which are connected, often wirelessly, to wider networks. The objects in question are often things that would traditionally not be thought of as being digital or ‘smart’. A good example of this is the IoT toothbrush (De Saullès, 2017). Whilst at first glance there seems little benefit in having a connected toothbrush, it does highlight the main objective of the IoT: to capture data. IoT is closely connected to the concept of big data (Batty, 2013) and the ability to process huge amounts of data to make better decisions. This is the same basis on which much city wide IoT infrastructure is deployed, to capture as much data as quickly as possible. In all these debates around IoT and big data there is a question of who benefits most from the relationship between user of a product or service and the company harvesting the data from that product or service (O’Neil, 2016).

Connected toothbrushes may be a little frivolous, but IoT applications can be deployed in more critical areas of society. In a rural context one such use of IoT is around the provision of remote healthcare. It is well recorded that rural areas have a greater proportion of older residents than urban areas. This presents issues of service delivery particularly where the elderly residents suffer from long-standing and complex medical problems. IoT devices are a way of delivering both medical care remotely and allowing patients to manage their own care to a certain degree (Philip et al., 2015). Another example of a rural application of IoT technology is around the management of medical information in an emergency. It can take emergency responders much longer to reach a patient in remote rural areas. To mitigate this in many rural areas local people are trained as First Responders to offer some medical assistance before the paramedics arrive. A research program in Scotland has investigated whether smart connected devices can be used to share medical information between the first responder and the paramedic whilst they are on-route saving vital time once they arrive (Mort et al., 2015).

As with CAVs, IoT applications can only be deployed to rural areas once connectivity problems have been overcome. In many cases the data needs to be transferred back to a central point for processing. This is difficult to do where there are significant amounts of data being transferred especially in the case of poor broadband or mobile connections. Another issue is that IoT solutions often replace human contact with digital contact. The IoT healthcare outlined by Philip et al. (2015) highlights how improved digital healthcare could mean that human health providers no longer visit socially isolated older people. This can be seen in other areas with internet shopping replacing face-to-face shopping experiences. All this can further atomise the lived experiences of rural communities (Hage et al., 2013).

Indeed, the delicate balance between providing essential health care, while at the same time battling social isolation, strongly came to the fore during the Covid-19 pandemic. The common adage is that e-health should primarily complement regular health care, and when e-health is applied the application should be adapted to the context in which it is used (e.g. a rural vs. an urban community -Hage et al., 2013). Within a very short time frame during Covid-19, this adage took a back stage and regular health services were replaced by online health services as much as possible. Acknowledging the magnitude of this rapid shift, one can nevertheless question whether this ‘digital by default’ style operation works for all types of less digitally included users, such as older people in rural communities (see Mariën et al., 2016 for a more general critique of ‘digital by default’ policies). Rural-proofing IoT based e-health services seem to be a key societal challenge for the near future, which has become even more urgent because of the Covid-19 induced acceleration of developments.

On the positive side, IoT solutions have the potential to deliver services to rural areas at much reduced costs. This is seen in the medical applications already outlined but also in other key services such as waste management. For example, Smart Bins⁵ tell the waste authority when they need collecting. At the moment a bin collection service visits every bin each cycle irrespective of whether it actually needs to be emptied. If a bin was only visited when it needed to be emptied, in rural areas this could save significant cost.

IoT also offers the potential to incorporate gamification into everyday rural practices. The Merrim-Webster⁶ dictionary defines gamification as: “the process of adding games or game-like elements to something (such as a task) so as to encourage participation.” In the case of smart bins, communities could be rewarded for minimising the frequency of collection for their bins, thereby encouraging behaviour change with economic and ecological benefits. The cost savings or a proportion of them could be added to a community fund to further incentivise participation.

The potential impact of IoT in rural areas is a very good example of the possible second order societal effects from the introduction of what, on the face of it, appears to be a benign technology. Inevitably such technological change will have an impact on the structure of society and the agency of individuals within that society. Evidence to date suggests that these technologies require particular rural conditions and have particular rural outcomes (Hage et al., 2013; Philip et al., 2015; Salemink et al., 2017). Agriculture is one area where IoT is already starting to have an impact, for example through the application of sensors to monitor animal movements and virtual fencing to restrict said movements (Marini et al., 2018).

3.3. Smart grids

The final technologies to be considered are smart distributed grids. A distributed grid is “is a socio-technical network characterised by the active management of both information and energy flows, in order to

⁵ <https://www.smartbin.com/>.

⁶ <https://www.merriam-webster.com/dictionary/gamification>.

control practices of distribution generation, storage, consumption and flexible demand” (Wolsink, 2012: p824). This is one technology where rural areas have in some senses progressed more quickly than urban areas. A number of remote and island rural communities have already adopted smart grids as a means to achieve sustainable mains electricity without the need to connect to the national grid (e.g. Chimiel and Bhattacharyya, 2015). Traditionally electrical energy has been generated in large scale power stations and transmitted to the end users via a national grid (Wolsink, 2012). The advent of renewable energy has challenged this model of generation and delivery (Wright, 2018). The intermittent nature of most renewable energy sources and the rapid development of large-scale battery storage means connected smart grids are now being developed as a response to these structural changes in the way electricity is generated and used. What is interesting about smart grids is that they turn passive consumers into active managers of a common pool resource (Wolsink, 2012). The development of rural smart grids offers a number of benefits for the host areas: greater resilience in the supply of electricity; if the community have a degree of ownership of the system there is the opportunity to capture more economic value locally; and finally, there is a greater incentive to make the shift to a low carbon economy.

Smart grids also again highlight the need to consider the relationships between the various technologies when considering their impact on society. It is anticipated that electric vehicles will be a key element in smart grids. A study in 2012 (Bates and Leibling, 2012) estimated private cars spend 95% of their time parked. If this is replicated with electric cars, it is possible for them to be connected to smart grids and allow their batteries to regulate the peaks and troughs of renewable energy generation. As CAVs begin to replace conventional cars, this assumption may not hold true. Early adopters of CAVs seem to be ride-hailing services such as UBER (Shepardson, 2019). Large companies such as UBER are able to fund the high start-up costs associated with the initial development of CAVs. This means they are also able to dictate the way the business and use-case models for CAVs develop over time. If the future of cars is not private ownership but is as part of an on-demand service (particularly in remote rural areas with poor transport infrastructures), are the cars then more likely to spend much less time idle and therefore not available to plug in to smart grids? This example shows how a lack of thinking at a systems level might lead to unintended consequences.

For rural development, consideration is needed to challenge some of the assumptions being made about 4IR so that rural areas are at the centre of any developments, not in the periphery. To achieve this, new research is needed which brings together thinking on new technologies and their impact on society, with existing influential rural development paradigms such as neo-endogenous development (Ray, 2006) and the rural idyll. The next section of the paper considers the various smart technology and rural development research domains and considers how they can be applied to new research concerned with smart rural futures.

4. Bridging smart rural and smart urban research discourses

As outlined above, much of the previous research and literature on rural technology has focused on digital connectivity and the availability of broadband. The preceding discussion has outlined some areas where new technologies from 4IR could have, and in some cases already are having, a significant impact on rural areas. However, little, if any, research has been carried out into the remaining technologies being developed under the 4IR umbrella or on the combined effect of the various technologies within the 4IR umbrella on rural areas. Technical research is needed into the practical aspects of deploying such new technologies in rural areas. More importantly, though, such research needs to be undertaken in parallel with research into the specific socio-technical systems that will develop as such technology becomes part of everyday rural life. These technologies, and particularly how they combine and interact with each other, needs to be understood at a

societal level.

4.1. Rural research including 4IR: looking forward

At the moment the debate is dominated by the impact these next generation technologies will have in cities. Much of the current sociological and critical human geography research into smart cities is starting to challenge the technological determinism that was evident in some of the early smart city research (for example Hatuka et al., 2018 or Kitchin, 2014). This has been accompanied by critiques focused on the way the new socio-technical systems have been developed within neo-liberal paradigms (Kitchin, 2014) and serve to reinforce the existing power relationships and inequalities in society (Grossi and Pianezzi, 2017).

To take on the challenge of researching the impact of 4IR on rural areas there are a number of inter-related challenges that need to be faced. The first of these is that rural research needs to turn its gaze to the future, something that has often been neglected (Woods, 2012 & 2019). There have been a number of attempts to engage in futures research in a rural context. One of these was the UK Government Office for Science’s Land Use Futures Programme which took place in 2008 (Dwyer, 2011). This looked at the very long-term future and used a foresight methodology to create scenarios of possible futures (GoS, 2010). Previously a study by Lowe and Ward (2009) had also used a scenarios-based approach to envisage the future for rural areas. A new Horizon 2020 project (DESIRA) is using foresight workshops to explore potential digital futures for rural areas across Europe. Turning the research gaze to the long-term future will allow a systematic and synoptic approach to be taken to rural development and technological change. Future thinking research allows us to consider a range of possible futures and to work with local communities to develop appropriate pathways to the most desirable (or inclusive) outcomes. This approach is particularly appropriate for exploring the impacts of digitalisation and can empower national and local government, and support agencies to proactively support rural communities to benefit from these developments. This approach also allows for more interdisciplinary research (e.g. Miles, 2010; Lowe and Ward, 2009). This is essential if the many second and third order effects of the developing technologies are to be understood. Finally, future thinking research enables the structural changes affecting communities, for example climate change, demographic change etc. Often termed ‘wicked problems’ due to their complexity, to be incorporated within the research processes (Tewdwr-Jones and Goddard, 2014).

4.2. 4IR and networked rural development

As research into 4IR looks to the future it will need to consider issues of power, control and agency. One particular strand of rural research that has considered these issues over the last couple of decades is that of networked rural development. This developed as a way of bridging the gap between endogenous and exogenous models of rural development (Lowe et al., 1995). Drawing on the work done by Cook and Morgan (1993) and their theory of a ‘network Paradigm’, networked rural development looked to a complex web of linkages and knowledge flows between actors in a particular network (Murdoch, 2000). The application of 4IR to rural areas is a classic example of networked rural development. It will be a blend of exogenous and endogenous actors and knowledge. Where it is arguably different to the network paradigm considered previously is that it goes beyond the narrow confined approach of economic development to include networks of regulation and governance.

In addition to the need to broaden the scope of the networks being considered, there is also a need to consider “which resources are mobilized, identities fixed, and power relationships consolidated” (Lowe et al., 1995: 103). Many of the technologies are controlled and promoted by large multi-national companies with very specific agendas to pursue.

Many urban communities are in what seems like an uneven relationship with these large tech companies in relation to large scale deployment of 4IR technology. A good example of this can be found in Sidewalk Labs high tech neighbourhood in Toronto. Even in the early stages questions have been raised around the democratic legitimacy of the project, the transparency of decision making and the relationship to local stakeholders (Valverde and Flynn, 2018). Could the same uneven relationships arise in rural contexts? In Agriculture, the values and decision-making of those shaping innovation processes (including designers and technology firms) already favour certain actors – for example large farms which are more able to engage with and access technological applications (Bronson, 2019). Using a networked rural development approach, it is possible to examine these critical issues of power and control in these emergent technological networks.

Taking a networked approach to 4IR also allows issues of peripherality to be considered. As we start to develop these digitised networks they will potentially reach into multiple aspects of rural society which impact upon the relationship between space and place. This has been an issue in spatial planning for some time, where the relationship between traditional Euclidean concepts of place and space have been challenged by a more relational approach which encompasses social and cultural representations (Graham and Healey, 1999). 4IR is likely to further blur the line between these two concepts of space. A networked approach to research on 4IR therefore needs to pay attention to both the physical networks of the technologies, but also the social and cultural aspects of space and place. The issue of peripherality has always been about more than just geography and 4IR will shift the emphasis away further, with intersecting offline and online realms of society.

As rural networking has been found to be rather distinct from urban networking (see e.g. Townsend et al., 2016; Roberts and Townsend, 2016) it is also of great importance for rural research into 4IR to develop distinct theoretical frameworks to understand the implementation, role, and impact of 4IR in rural development. Both rural areas and rural research have distinct qualities in comparison to urban areas and research. Academic and political debates tend to be urban-centred and develop rapidly (Bock, 2016) and this means that research into urban 4IR development will continue to set the tone for the academic debate. However, it is up to rural researchers to rural-proof 4IR concepts and findings, and, if necessary, develop distinct rural concepts to avoid the misfit of the urban mould. One might say that peripherality then becomes a quality, both of rural areas and in rural research, albeit in a different way than the rural idyll scholar originally advocated.

As part of the networked approach, attention will also need to be paid to epistemological issues framing the debate about how 4IR will be governed and regulated. At the moment there is a clear preference for a market led approach with private enterprise taking a lead. However as 4IR seeks to expand into rural areas, issues about the provision of infrastructure and access to services become more critical. As was highlighted in relation to CAVs, much of the 4IR technologies require physical infrastructure to operate. Should rural areas benefit from a universal service obligation imposed on such technologies? Alternatively should national or regional governments seek to step in and fund required infrastructure to ensure rural areas are able to benefit from the new technology as it develops? This has been the dominant discourse in earlier stages of rural digital development, with examples of failed promises such as the UK Government pledge for universal broadband access for all with speeds of at least 2 MBPS by 2015 (Townsend et al., 2013). Alternatively, ‘Smart Platforms’ aim to allow a range of developers and businesses to use the platform to develop their products and services (for example Cisco’s Kinetic Platform⁷). It would be possible to develop a similar platform approach for rural areas but the governance and control of such a platform would need to be considered.

4.3. 4IR and rural research beyond agriculture and the rural idyll

The final challenge in developing new research for a smart rural future is ensuring many of the existing discourses are not incorporated into the next generation of technology unchallenged. Discourses such as the dominance of agriculture and primary production in the rural economy and the notion of the rural idyll are still very present in today’s debates around rural development policy. This can be seen in the OECD’s draft Principles of Rural Policy (OECD, 2019) which states: “the opportunities in rural areas go far beyond agriculture.” Indeed, many of the “smart” technologies already operational in rural areas are restricted to agricultural settings, and even then, with a bias towards the larger farms with more capital to invest in large-scale hardware and expensive software with annual licensing fees (Kerneck et al., 2019) – this was a strong theme emerging in the Horizon 2020 “Agrilink” project, which researched the uptake of precision farming technologies (and other innovations) on farms across Europe.

There is a significant risk some of these accepted technological biases in rural areas will be enveloped within the new technological paradigm, written into the algorithms, and thus become hidden from view and therefore significantly harder to challenge and reverse. To take strategic planning as an example, there is a clear trajectory of development that is already underway. It has long been recognised that the discourse of sustainability has enabled a restrictive approach to housing developments in rural communities (Sturzaker and Shucksmith, 2011). A certain set of criteria is used to determine whether a community is deemed to be ‘sustainable’ and if the community fails this test development is restricted. Currently, the criteria to determine sustainability is relatively transparent and open to challenge however with the digitization of the planning system it is highly likely that these criteria for judging sustainability will become hidden within black-box planning decision systems, often developed by third party providers and therefore protected from scrutiny by intellectual property rights. Other domains of rural development such as healthcare and public transport are equally susceptible to similar processes with current presumptions and perceptions of the rural situation being embedded within the new systems. Therefore, research which interrogates these potential biases is critical to ensure a responsible innovation process for rural regions.

5. Conclusions

This paper has set out to move the debate about smart rural development beyond broadband connectivity and the urban-rural digital divide. It draws its inspiration from Newby’s 1984 paper which looked at the potential rural impact of the initial digital revolution. History has shown the high hopes for rural digital connectivity as outlined by Newby have not been fulfilled. Rural areas remain left behind in terms of broadband and other digital connectivity, not to mention in terms of digital adoption and skills. This paper argues that rural areas may also be in danger of being excluded from the development of the next generation of technologies being developed as part of 4IR.

An examination of three of these technologies in the context of rural development has shown their potential impact could be just as important in rural as in urban development. However, many of the technologies are being developed to address issues of density facing cities and urban areas. Rural areas do not suffer from the same issues and problems. Smart rural futures therefore need to be framed differently from smart cities research. Can these technologies address specific rural issues around connectivity and peripherality? The snapshot case studies highlighted in the paper suggest they can, but this is not a certainty as there are many physical and socio-cultural barriers to overcome to ensure rural areas do benefit to the fullest extent.

What is distinctive about the next generation technologies, is the cumulative impact they are likely to have on different places. This cumulative effect has potential to reach all elements of society and therefore research into its effects needs to be broad and

⁷ <https://www.cisco.com/c/en/us/solutions/industries/smart-connected-communities/kinetic-for-cities.html>.

interdisciplinary. It needs to build on existing research paradigms and approaches such as RRI and future thinking research, as well as concepts including networked rural development to map out a coherent research framework. We propose a movement towards “*Responsible Rural Research and Innovation*” (RRRI) as a sub-field of RRI, which brings together these approaches in a specifically rural context. Such research should examine not just the practical and physical aspects of 4IR but also issues of power, control and agency in the way the technology is developed and applied to rural areas. The rural should no longer be the tailpiece of urban-centred research on smart development and 4IR. Instead, peripherality should be the starting point for distinct rural research into smart rural development and 4IR technologies, and the distinct outcomes these will have on rural communities.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2020.08.042>.

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