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The implications of 5G networks: Paving the way for mobile innovation?

1. The impact of 5G

The telecommunications industry is on the cusp of adopting a new generation of mobile technologies. This fifth generation (5G) promises far-reaching changes, with the high-speed wireless broadband that it provides changing the way that individuals and businesses use telecommunication services. Through 5G the quality of telecommunication services will improve, with better signals being received inside buildings and latency and jitter significantly reducing so that new services can be developed. These new services are often associated with vertical sectors such as the automotive industry, healthcare, logistics and energy. It is these vertical sectors that are the heart of the socio-economic benefits that many believe 5G will create. Moreover, 5G is central to the Internet of Things, where the massive amounts of data generated will facilitate productivity improvements as well as lead to entrepreneurial activity across the economy.

Given the widespread socio-economic benefits associated with 5G, it is not surprising that policymakers are also interested in its development. If policymakers can position a country or region so that it gains an early lead in 5G and/or key vertical sectors, then it may be able to thrive in the highly competitive global market that is expected to emerge. Of course, as 5G roll-out plans in the majority of countries are still being defined and services have not been launched, the challenges for policymakers are significant. The wrong decisions may be made, and the country or region does not prosper as much as it could have done if a different course of action had been taken. Moreover, the decisions taken by policymakers may result in digital divides emerging.

The impact of 5G is far-reaching. It will impact on the telecommunications industry, not only in terms of how 5G services are rolled-out but also in terms of who provides services to customers. The emergence of 5G-enabled vertical sectors could fundamentally change telecommunication markets, forcing telecommunication companies in less lucrative roles than was previously the case. The innovative activity associated with vertical sectors may benefit many, but unless 5G networks are everywhere some will inevitable not benefit to the same extent. 5G, therefore, raises a number of issues that require further thought. The articles of this special issue, which were solicited through an open call for papers and peer reviewed, begin to address the complexity and dynamism of 5G and the wide-ranging socio-economic impact that its adoption and roll-out will have.

2. Main themes

In his article, 'Leadership with 5G in Europe: Two contrasting images of the future, with policy and regulatory implications', Wolter Lemstra analyses topics that are relevant to the policy and regulatory debate in Europe concerning 5G. The first part of the article describes the factors that have led to the success of 2G-GSM and what 5G could learn from them. The second part assesses two approaches, which are called images by the author, that could be employed by policymakers to understand different implications of the realization of 5G. These are 'Evolution' and 'Revolution'.

The 2G-GSM success is presented as a case of European leadership. The technology was developed within Europe and various governmental- and market-related factors contributed to its success. Examples of such factors are the harmonized use of a particular radio frequency band, the development of an open standard, the availability and mutual recognition of terminal devices, the creation of an EU-wide market through roaming and the introduction of competition. The author proceeds to analyse the cases of 3G and 4G-LTE and draws several conclusions regarding the possible leadership opportunities with 5G. The employment of virtualization and application programming interfaces (APIs) is described as an important enabler of the development of vertical industries.

The 'evolutionary' image corresponds to a continuation of previous mobile networks generations (1G, 2G, 3G and 4G), whereas the 'revolutionary' image implies a clear break with previous developments and requires focusing on new technological developments

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such as virtualization. To sum up, this article raises a number of issues that European policymakers need to address in order to create the necessary conditions for the development of and leadership by Europe of the 5G arena.

The second article – '5G networks: Will technology and policy collide?' – is by Zoraida Frías and Jorge Pérez-Martínez. The paper deals with the technical features of 5G, as well as regulatory aspects at the European level. Moreover, it also deals with net neutrality and discusses its pros and cons within this particular context.

More specifically, the paper deals with the idea that despite being still under development, it is envisaged that 5G networks will provide a 'fibre-like' experience to mobile users. As such, 5G is expected to accommodate services with very different requirements in terms of latency, bandwidth and reliability, among others, for a range of vertical sectors. However, the European Union has just approved the Telecommunications Single Market Regulation, which enshrines the network neutrality principle and guarantees that 'all traffic through the Internet is treated equally'.

In addition, this article explores the potential conflict between net neutrality regulation and future 5G services, particularly regarding network virtualization. The authors present a discussion on the challenges of building net neutrality based on judgements as to whether traffic optimisation is objectively necessary. This proves complex in a technological environment that envisions 'network slices' created and priced on-demand according to the Quality of Service (QoS) required by specific applications at any given time. In addition, they argue that the 'anything-as-a-service' paradigm might turn into an important source of innovation for the future Internet infrastructure layer, and thus for the ecosystem as a whole.

This paper suggests topics for future thought such as that the issue is no longer whether imposing 'neutrality' will prevent the creation of fast and slow lanes on the Internet, but rather whether technology breakthrough can meet an increasingly heterogeneous demand in ever more efficient and transparent ways. While regulatory instruments are often examined to better enforce the rights of users and safeguard competition, the key may be in future technologies whose development could be prevented by the current rules.

In their paper, 'On regulations for 5G: Micro licensing for locally operated networks', Marja Matinmikko, Matti Latva-aho, Petri Ahokangas and Veikko Seppänen draw a comprehensive picture of future 5G networks in the broad context of the wireless provision of information and communications services. They focus on the specific capability to provide new services for case-specific needs of various vertical industries. They show that 5G technologies can be expected to disrupt the mobile communication business ecosystem and propose a practical and radically new sharing based network operational models. In particular, the 5G technical features of 'network slicing' and small cell deployments will lower the investment threshold for new entrants to offer vertical specific services in specific areas and allow them to lease the remaining required infrastructure on demand from mobile network operators (MNO) or infrastructure vendors. For this to actually happen, existing regulations governing the mobile communication business ecosystem and locally deployed networks need to be re-visited.

This paper provides guidelines for the development of the key micro licensing components. The paper outlines the technical capabilities offered by 5G to cater to the specific needs of particular activities, and the possibilities to transform the wireless services provisions business eco-system. As the industry 4.0 redefinition is underway, the nascent 5G will take shape in transformative ways.

The rollout of a 5G network is explored by Edward Oughton and Zoraida Frias in their paper 'The cost, coverage and rollout implications of 5G infrastructure in Britain'. After acknowledging the socio-economic importance of information and communication technologies (ICT) and noting the problems associated with poor connectivity, attention turns to the rollout of 5G in Britain. A short literature review highlights a set of key features that shape, to a lesser or greater extent, the roll-out of 5G that is subsequently investigated. A key technical issue is the network densification associated with 5G, which has, of course, cost implications. The lack of research that explores the spatial rollout of telecommunications technologies over time is also highlighted, thereby illustrating one area in which the paper contributes to the literature.

To explore the rollout of 5G across Britain, a sequential methodology is adopted. The methodology adopted is outlined in detail in the paper, though at its core are three elements. By identifying seven different geotypes, a granular analysis of the rollout of 5G infrastructure is undertaken. For each of these geotypes, the cost characteristics – for example, population density – are determined before the costs of meeting two different demand related scenarios are assessed. Finally, the costs are calculated to meet specified demand.

Through this methodology, the paper sheds light on the roll-out of 5G across Britain. A 'baseline' scenario, which assumes that it starts in the most densely populated areas first, finds that London is favoured over Scotland. By amending the amount of capital expenditure, the analysis illustrates how lower capital expenditure reduces the proportion of the population covered in the first year while increasing it results in the 5G network covering a lot more of the population. These changes also affect how long it will take to cover 90% of the population with 5G; if £2.5 billion is spent per year this would take five years, whereas if the capital expenditure is reduced to £1.5 billion per year this would take eight years.

Interestingly, the analysis also draws attention to how under a 'business as usual' approach to infrastructure the market does not provide coverage to everyone. However, if infrastructure is shared, those areas with low population densities like Scotland see the largest cost savings. Attention is also drawn to the high costs associated with rolling out 5G to everyone, with covering the last 10% of the population costing more than the first 90%.

The paper concludes by outlining a series of policy implications that emerge from the analysis. While some of the issues discussed, such as Brexit – that is, the UK's decision to leave the European Union – are specific to Britain, many others are not. Infrastructure sharing is identified as a way to reduce the costs associated with 5G infrastructure rollout, while a competitive market, it is argued,

encourages the deployment of infrastructure. It is also suggested that the impact of spectrum and coverage obligations on 5G rollout could be included in future.

The final article in the special issue – 'How disruptive is 5G?' – is by Martin Cave. The paper deals with the hypothetical market structure of mobile markets induced by the adoption of 5G. It also deals with the challenges and opportunities faced by the mobile carriers, as well as the likely changes envisaged for regulation.

The hypothesis is put forward that, after three decades of relative stability, there is now the prospect of significant change in the vertical and horizontal model of competition in mobile markets. On the supply side, significant factors are, firstly, the availability of a new and very powerful form of mobile connectivity in the shape of 5G, and secondly, software defined networking, which allows a single network to provide a variety of heterogeneous services or 'slices'.

On the demand side, the digital transformation of the whole economy (and not just the communications sector) creates the need for diverse communications functions operating in a universe with a much wider set of digitally transformed services. Mobile operators will find themselves contesting customer relationship with firms or other organisations providing these services in an integrated fashion, and thus risk replacing their direct link with end users with becoming the wholesale supplier of an expanded but 'commoditised' communications product. The article suggests that through these changes we are likely to observe fewer radio access networks, more competitive backhaul, and the (partial) vertical disintegration of mobile network operators.

The regulatory changes implied may include the heavier regulation of fewer radio access networks (RANs), and the need for market analyses to confront situations in which network operators sell more and more of their services to ever fewer end users, and to a variety of heterogeneous content and application providers, with some of them exercising substantial levels of market power.

This paper also suggests that regulators might be confronted with the prospect of mobile and fixed operators being relegated to a different role in parallel with their traditional one, that is, as sellers of variegated network components to service providers which will own and control the relationship with the customer. This will require market analyses with a different focus and different level of countervailing market power than is exhibited at present. Finally, the developments described in the paper are likely to require a review of current net neutrality regimes to the extent that they outlaw the provision by internet service providers (ISPs) of bespoke services to particular content and application providers.

3. Emerging issues

The articles in this special issue cover a broad array of topics, ranging from the technical characteristics of 5G to the regulatory challenges that it creates and the opportunities for (global) economic leadership. That the issues addressed in the papers are diverse reflects both the ongoing development of 5G, but also the widespread recognition of its socio-economic significance. Having said this, the articles also suggest a number of areas where future research is likely to emerge.

Firstly, although 5G is still being developed, it is widely accepted that it will provide a 'fibre like' experience. The resulting services will be characterised by their diversity in terms of latency, bandwidth and reliability across multiple and often quite different sectors. It is not clear how this diversity, which will also be spatially and temporally dynamic in character, will shape the roll-out, dimensioning and subsequent operation of the network. That the roll-out of the network is likely to reflect demand and new (emerging) economic opportunities raises a second area where research is needed, namely, understanding those factors that shape the expansion of network coverage. Key to this will be understanding the pace of network roll-out, identifying not only where the network will first be launched but also the emergence, viability and commercial success of new services that will drive its adoption.

There is considerable enthusiasm among many commentators for 5G, not least because of the wide-spread socio-economic benefits associated with the emergence of vertical sectors. These sectors, which are spread across the whole economy, will see 5G being used in new and creative ways and thus adding socio-economic value in numerous different ways. Thus, a third area of research will explore the business models facilitated by 5G. Significantly, the business models developed by companies operating in the vertical sectors will have far-reaching implications across the whole economy, affecting not only competition within the vertical sectors themselves but also the strategies adopted by mobile network operators who need to recoup the costs associated with 5G. While policymakers and consumers alike may welcome the innovation and competition associated with vertical sectors, how these will shape the development of the wider ecosystem is unknown. Will, for example, the value creation inherent to the growth of the vertical sectors come at the expense of the ability of mobile network operators to invest in infrastructure?

The alleged socio-economic benefits of 5G has already attracted the attention of policymakers. In the future, the role and actions of policymakers with regards to 5G will be shaped by the interaction between two related yet separate areas. Policymakers will initially be motivated by a desire to ensure the widespread availability of 5G, but as these networks are rolled out this will be complemented, and then overtaken, by their desire to maximise the associated benefits through, for example, facilitating the development of dynamic and innovative vertical sectors. Thus, a fruitful area of future research is likely to emerge around issues that identify the initiatives and tools that policymakers can employ to shape 5G related developments and importantly assess their effectiveness. This research will need to occur at different geographical scales, as 5G and the markets that it will support operate nationally, internationally and globally. Moreover, as these markets are dynamically linked together, there is a need not only to develop appropriate theoretical frameworks to understand these linkages but also to engage in comparative research covering the whole 5G ecosystem.

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