5G Business Models: Evolving Mobile Network Operator Roles in New Ecosystems

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Abstract— **This paper attempts to shed light on future 5G business models. First, it analyses how telecommunications business models may change with the adoption of 5G and network slicing technologies, emphasizing their impact on control and value aspects. Second, it reviews and extends current literature to describe and discuss six business model configurations for a future 5G context, focusing on the role of mobile network operators. For example, we propose a specific arrangement for socially valuable ecosystems such as smart cities. Overall, these models apply to diverse settings and will differ in terms of market concentration, the value propositions of connectivity service providers, and the implications for innovation and competition.**

Keywords—5G; Business models; 5G ecosystems; Smart cities

I. INTRODUCTION

5G architecture and technology aim to enable new use cases in multiple verticals, and will support massive amounts of connected devices [1-2], thus allowing smart city ecosystems to flourish. Currently, 5G investment efforts are increasing, and the schedule for implementation is accelerating: most European regulators have either announced auctions of 5G spectrum or have already held them, and dozens of new trials and demonstrations have been performed. However, even though European mobile network operators (MNOs) are announcing their plans to roll out fifth-generation networks in the upcoming years, their 5G business models remain unclear [3]. Moreover, while there is an expectation for demand growth from profitable applications, vertical industry companies are still skeptical about the promised business cases [4]. A main concern, especially among MNOs, is how to monetise 5G investments in a context where data is commoditising.

Even though mobile data traffic is growing substantially, European MNOs face stagnant revenues and yields per user [5] and high churn rates [6]. In addition, coping with increasing network capacity requires them to invest massively in network infrastructure, besides the purchases of spectrum licenses. Their networks are then used by over-the-top (OTT) content and application providers that do not share such spending. Until now, operators have responded with price cuts and bundled offers, but are still struggling to find a sustainable business model to monetise their offerings. With 5G there is potential for growth, but increased competition can be expected to arise from the softwarization of networks and from new technology companies entering the connectivity provision market. Therefore, with a changing future competitive landscape, and potential advantages and profits accruing to multiple stakeholders, it is important to find valid business models which share the objective of helping create and sustain 5G ecosystems.

However, developing a profitable business model is especially challenging for general-purpose technologies, defined as widely used innovations that require and are capable of subsequent innovation in multiple sectors, thereby having an impact on the whole economy [7]. It will be crucial to foster the timely emergence and adoption of new use cases in different vertical markets, as well as to take into account and leverage the impact of 5G and network slicing technologies on value and control aspects.

This paper presents a comprehensive and novel analysis by aggregating and extending current literature. In what follows, section II will start analysing the impact 5G will have on future business models. Next, section III will describe six potential 5G models, focusing on the role of mobile network operators and of new ecosystems. To conclude, section IV will discuss the implications of the present analysis.

II. IMPACT OF 5G ON BUSINESS MODELS

In this section, we describe the general impact of 5G and network slicing technologies on future telecommunications business models. In order to do so, we follow the framework in [8]. We understand business models as designs intended to show how value within an entire ecosystem is created, how it flows, and how it is captured, while emphasizing the alignment between control and value. Therefore, we analyse the impact of 5G in future value networks' functional architectures, the interrelations and hierarchies among their roles, their financial models, and the value propositions made to the users.

A. Control: Distribution of assets and intelligence

Control refers to the distribution (or concentration) of essential resources within the value network. Such control will be key in driving business model designs and determining the structural roles and their power interdependencies.

Spectrum licenses are a key asset determining control structures in telecommunications value networks. Ownership of licenses brings a competitive advantage to the licensees, as it gives them the right to use a certain frequency band and bars its use by others, thus ensuring an oligopolistic market and protecting the licensee from outside competition. By leveraging the control over the scarce resource that licenses provide, MNOs have traditionally been able to capture a solid share of the returns within the value network. Hence, spectrum can be considered a bottleneck asset, i.e. an asset that is in high demand but not competitively supplied [7]. However, the distribution of economic returns from a technological innovation, and in turn its success, can be determined by complementary (bottleneck) assets [9]. In this context, complementary assets are those that, while not part of the connectivity service, are needed to offer a profitable value proposition and experience to customers, whose satisfaction does not necessarily arise from the connectivity itself. Therefore, control over such assets affects profitability prospects, which in turn will determine initial and continuous investment in 5G technology and affect its adoption.

Valuable and scarce assets, complementary to connectivity, include the following: (i) media content, which caused a redistribution of returns from connectivity service providers (CSPs) to OTT players, and thus the aforementioned urge by MNOs to merge content within connectivity offerings; (ii) customer data and analytics, which open up new sources of revenue (e.g. from other products or advertising), aid decision-making, and help tailor products to customer needs and predict demand changes; (iii) size and network externalities, which can represent the main source from where to extract rents out of an ecosystem; and (iv) other assets related to a specific use case. Examples of the latter include broadcasting or streaming rights, ownership of the site of a crowded event, and operating systems or other software behind, inter alia, smart driving applications or industrial artificial intelligence (AI).

With 5G, a greater distribution of intelligence can be expected, through a shift from cell-centric towards user-centric design [10], and from functions being moved to the terminal or the edge, which can allow real-time data processing and reduce latency [11-12]. Softwarization and virtualisation technologies permit architectures where functions are decoupled from the physical structure, and where CSPs can offer certain control and self-management over certain functionalities to connectivity service customers (CSCs).

B. *Value: financial model and value proposition*

While 5G will bring radical technological improvements, enhancing the quality-of-service (QoS) of connectivity offerings and supporting emerging use cases [13-14], network slicing can add further value by tailoring value propositions to consumers and enterprises in a cost-efficient manner. Network slicing allows for service customization and for physical infrastructure to be shared among distinct virtual networks containing different network functions, and among multiple tenants [15-16]. The resulting flexibility is a key enabler business-wise, as it will allow operators and third party service providers (SP) to launch their services in a more agile way, reducing time-to-market [14-17]. In addition, network slicing can yield cost efficiency, as it allows to allocate into each slice only the necessary network functions and resources required by each specific use case and tenant [18], making use cases with very specific requirements more feasible. It will also allow to provide niche customers with tailored offerings for a lower cost than current technologies would [19]. Therefore, 5G will relief the dichotomy between building capabilities to target particular market segments versus serving mass market needs. Lastly, network slicing enables new roles, separating infrastructure providers, slice tenants, and end users [19].

Regarding customer value, products and services compete on a triad of counteracting or collectively exclusive attributes that shape the value that they deliver to customers, namely operational excellence, product leadership, and customer intimacy [20]. Nevertheless, 5G and network slicing constitute radical innovations that can make it superior to previous generations in all three aspects: it can bring improved and bespoke performance together with cost efficiency.

Over the recent years, competitive pressures forced operator models to evolve toward bundled offers, merging traditional connectivity services and adding complementary products, e.g. entertainment. Integrated CSPs are able to cross-subsidize among the different services and enjoy economies of scope, gaining a competitive advantage over mobile-only or virtual CSPs, while customers benefit from getting more value from a single source. Softwarization will only reinforce such convergence with OTT services as voice and even data transmission commoditize [10].

Similarly, revenue models may also evolve with the introduction of network slicing, since the technology will allow to better segment markets and tailor offers. Adaptive revenue models could use price discrimination to serve target customer niches willing to pay more for tailored premium performance, thus capturing more demand and absorbing extra consumer surplus. Further, dynamic pricing will be more realistic as virtualization and slicing help dynamically manage network QoS parameters, allowing to charge for the actual data consumed and the throughput, latency and other features offered at any given time to a differentiated customer profile [17].

Finally, active network infrastructure sharing among MNOs will be, with 5G, a more realistic and relevant cost-sharing scheme [21], since deploying dense 5G networks will require challenging infrastructure investments, especially in dense areas where vast small cell networks are needed. Furthermore, until 5G is ready to be commercialised, operators will have to invest in upgrading their 4G networks to cope with growing data demands [22]. Network sharing can reduce capital and operating expenses, thereby encouraging investment and accelerating deployment of 5G networks, especially in rural areas where small cells may have underused capacity [23]. It can yield environmental benefits as well, from less hardware being deployed and from lowering the energy consumption of base stations [24]. However, deep sharing agreements (e.g. involving the core network) may not be allowed as they may hamper competition and QoS differentiation between MNOs.

III. BUSINESS MODELS

Influenced by the findings in section II, the business models presented here differ mainly in terms of the control that CSPs, as core players to connectivity provision, exert over the value network, and in the extent of their value proposition. These represent the two main factors driving value creation and value capture within future 5G ecosystems. They also differ in terms of granularity and environment. Therefore, they are not mutually exclusive.

A. *Micro operator*

A micro operator (μO) is a CSP that does not own spectrum and only operates within a specific site or area [25]. Its business logic and viability arise from having a local monopoly within the space it serves [25]. The μO is dependent on the MNO for spectrum, and MNOs may offer a parallel connectivity service to the same area where the CSC is located. However, MNO business models are challenged if the μO owns bottleneck assets, which can be derived from (i) the inability of alternative CSPs to cost-effectively deliver the distinct QoS that specific use cases and sites require, (ii) from exclusive access to site-specific content (e.g. broadcasting rights for a mass event), devices and other resources, or (iii) from owning a small cell network [25]. To be successful, μOs need to serve specific requirements and be somewhat scalable, which would be possible from having a large enough user base, a large amount of data produced and used, enough demand for the specific content, or high user density [25]. Therefore, μOs make sense in environments like universities, hospitals, mass events or manufacturing plants [25]. Alternatively, μO models would be well suited for B2G safety-related scenarios, in which a μO would cover an infrastructure critical site such as a port, airport or power plant, where data are sensitive and subject to national security concerns. The μO would deploy and operate tailored slices with the requested reliability, latency and security, among other requirements. A main difference with current mobile virtual network operator (MVNO) models is that the role of the μO goes beyond that of an intermediary with customer ownership; rather, μOs potentially integrate on-site infrastructure and the provision of other services, or have exclusive access to bottleneck assets such as customer data or content.

B. Provider of XaaS

The most granular among the described business models for MNOs refers to the provision of XaaS, i.e. offering something as a service. This can be in the form of IaaS (infrastructure as a service), NaaS (network as a service), or NSaaS (network slices as a service). Even though these types of offerings could be part of a broader value proposition, here XaaS serves as the core proposition. Therefore, operators would act as specialized modular service providers within the value chain. Such a model would not be ideal for MNOs, as they would be less able to grab a substantial piece of the rents from the 5G ecosystem. However, the lack of control over certain bottleneck assets could push them to find it more economically feasible to specialise in network-specific service provision than to struggle seeking a more dominant business model.

Regarding infrastructure, not all operators may be financially able to invest in a nationwide 5G network. An IaaS operator can thus act as an asset provider, renting or selling some parts of the infrastructure to third parties [14]. This can also be done through independently-operated companies, like the recently announced 'TowerCo', a Vodafone spin-off. Providing IaaS can benefit other operators that may not have the resources to build their own network, while, for the owner, the extra profit can relief the financial stress from the investments. Furthermore, IaaS can also be provided to governments, cities, or vertical companies, involving, among others, deployments of small cell networks for smart cities. Once deployed, the infrastructure can be operated by a third party (e.g. another MNO) or by the IaaS provider itself. This IaaS provision can also be realized through new models, such as that of a neutral host, i.e. a non-operator third party who deploys and/or manages an open infrastructure, thereby spreading costs and making deployment more feasible [26], especially in middle-sized indoor locations [27]. The described settings contrast with today's environment where operators prefer an end-to-end use of their own infrastructures.

Likewise, NSaaS is the provision of highly tailored slices to CSCs, who can use and optionally manage a slice and even provide their own communication services on top of it [16]. NSaaS yields more autonomy to the CSC than providing the slices as part of a broader offer, while the design, configuration and time-to-market of new slices becomes simpler and shorter [17]. The provision of slices aaS can also be done via a Slice Broker entity, who manages requests and assigns resources to MVNO, OTT and vertical companies on demand [19].

C. Use case enabler

Next, we propose a business model that addresses B2B relationships. Here, MNOs aim at developing comprehensive and tailored solutions for specific use cases, in order to speed up their adoption and valorise an early position. In order to do so, operators have to offer more than connectivity or infrastructure as a service. For each use case they address, they will have to offer a tailored slice that covers the specific requirements, complementing it with added solutions and services such as support, maintenance, after-sales or technical advisory.

In addition, operators will have to build the necessary vertical-specific expertise and foster relationships with customers. A supportive approach as the vertical solutions are developed can yield an intimate and direct relationship, resulting in feedback and vertical-specific data to better understand customer needs, which in turn helps enhance the value proposition. If properly executed, it can also yield customer lock-in and valuable synergies. Further, MNOs can provide their partners with access to their infrastructure, knowledge and insights from its experienced staff and their network. A further benefit, as in the similar "solution provider" model in [28], is that the complete solution allows vertical companies to focus on their core businesses, specializing in what they excel and outsourcing the rest. These agreements may be accompanied by different kinds of financial arrangements, e.g. cost or revenue sharing models that reduce the asymmetry in upfront capital expenditures or future profits, thus helping reduce financial stress and aligning incentives, making dyads more likely. Furthermore, the specificity and application-oriented nature of the investments, coupled with the reciprocal commitment, can help reduce the cost of external funding and thus alleviate the strain of initial network investments.

Use case enablers need to establish a more dominant position within the value chain than XaaS MNOs; hence, they will need to control enough complementary assets in order to position themselves as the enablers of the value proposition and have a closer grip on their customers. Moreover, due to high specialization efforts, it may only be feasible for each operator to target a share of use cases, starting from those where this business model has the potential to add more value or where the operator has already developed some capabilities. As a consequence, competition among operators may appear only within the more complex or profitable use cases. Further, given that a specific use case's requirements will be mostly common among CSCs, once specialised capabilities are built, the operator has the opportunity to scale efficiently within that targeted vertical. Therefore, the present model can provide a strong competitive advantage for targeted use cases, but at the expense of reaching a wider market.

D. Ecosystem orchestrator

The fourth design is contingent on a decentralised ecosystem. In this model, an orchestrator plays the structural role of leading efforts in fostering (long-lasting) relationships beyond its direct customers, targeting a large scope of new valuable interactions within the ecosystem and seeking to be central in the development of it. A main objective of this model is to make sure, collectively, that the different 5G-enabled innovations are developed and gain adoption. Thus, such ecosystem may be better suited to yield continuous innovation, since concentration of control by one single entity may hinder future developments [29]. Not only will 5G require further innovations for its applications, but it can indirectly speed up the development of other technologies (e.g. AI), from the enhanced performance needed and the higher amounts of data that will be generated. However, capturing value from wide-impact technologies like 5G is challenging, and a lack of (inherently difficult) coordination can halt deployment and subsequent innovation [7]. 5G value networks may be very fragmented, comprising many stakeholders with different expertise and complementary offerings for different industries and customer segments. In such a context, an orchestrator, i.e. an entity that finds connections among different partners and encourages them to work together [30], can help foster the sharing of knowledge and resources and the interoperability of independent offers, boosting synergies that are shared throughout the ecosystem.

Analysing current industry trends, the importance of partnering with different stakeholders along the value chain becomes clear, not only for the development of standards but in order to build 5G ecosystems. MNOs are well suited to lead coordination efforts, from their role in network deployment and connectivity provision and from their current involvement in trials and developments. Furthermore, MNOs have high incentives to foster the timely adoption of 5G networks and use cases, as spectrum auctions will eliminate the value of the real option to delay investments. In addition, this may be a realistic way to respond to the threat that non-telecom players pose. They can also benefit from the loyalty of the partners within the ecosystem, which can identify the operator as an innovation leader and a trusted supplier. This operator orchestrator will have to empower partners to address end customers directly with offers enriched by its network [14].

By providing a central role, the orchestrator helps reduce the high transaction costs of a decentralised value chain, while its limited control still allows for an ecosystem that facilitates specialization and flexibility. Decentralized ecosystems bring competition at the modular level and enable fast innovation, but they may reduce profitability [7]. Therefore, while an orchestrator model may be well suited to foster the timely adoption of use cases, this model may be less feasible in the long run, since technological maturity may increase the pressure on companies to increase profitability. In turn, this may give way to integration in pursuit of capturing a greater proportion of the rents within an ecosystem.

Fig. 1 shows a value network comprising of three layers, namely infrastructure, architecture, and vertical-specific end products and solutions.

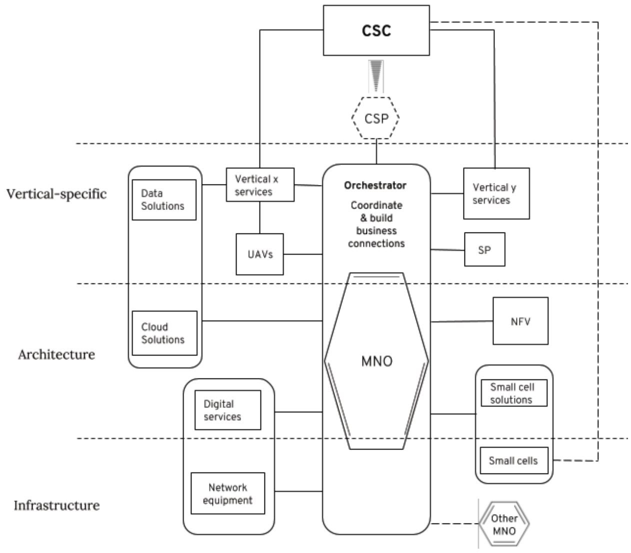

Fig. 1. Example of a value network for an ecosystem orchestrator model

The orchestrator serves as a reference point to which partners from the different levels willingly go in order to leverage other partners' expertise, share marketing efforts or even provide the final offer to the CSC. Fig. 1 also shows that MNOs can engage in active or passive cost sharing with other operators for certain network infrastructure elements.

E. Pervasive platforms

Pervasive platforms are entities that strive to dominate the value chain, seeking to extract a substantial amount of rents from it. They integrate many roles, possibly including that of CSP. Over the recent years, as described and forecast in [29], several platform types have been predominant, evolving from rather operator-centric towards device- or aggregator-centric. Such platforms, increasingly in the hands of IT and digital firms, are a threat to operators, who risk losing control over (part of) the value created on their infrastructure and being reduced to a network or connectivity provider role [29], e.g. a XaaS. This threat contributed to the increasingly bundled value offerings of MNOs in the past, and it will only increase in the future. Thus, we build on platform theory to extend the analysis on telecommunications platforms and adapt it to the 5G context.

Operator-centric platforms. Operator platforms (portrayed in Fig. 2) will be forced to compete beyond connectivity in order to exert a dominant position. Even though they would own a key bottleneck asset like spectrum licenses, in order to exert dominance over the value chain they need to integrate media content and tailored solutions for vertical industries, broadening the scope of current portfolios by trying to offer any service - from multiple service providers (SPs)- that can enhance the value proposition or improve customer experience.

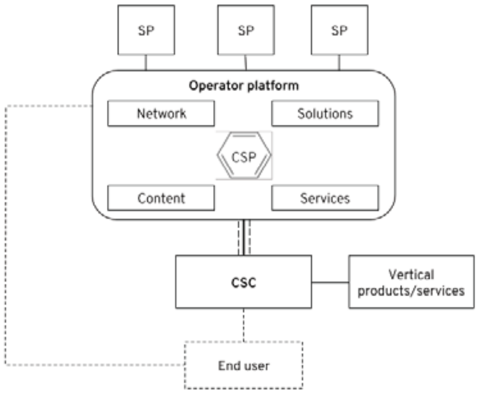

Fig. 2. Example of a value network for a pervasive operator platform

Operating system- (OS) and solutions-centric platforms. OS-centric platforms offer widely-used OSs that are embedded in all sorts of third-party or proprietary devices, through which users can access the platforms. These firms aggregate and create applications and content, and provide a broad range of software products (e.g. entertainment, office suite or cloud storage). The revenue models are varied: direct payments for applications, revenue-sharing schemes with creators or intermediaries, transaction fees for third-party sales within the platform, and advertising-based, freemium and subscription models, or a combination of the above. These platforms have prime access to important complementary assets such as wide customer and supplier bases and their data, and have the financial resources to constantly acquire innovators and technology developers, through funding or taking over ventures. Moreover, while they provide OTT offerings that take advantage of the interoperable nature of connectivity, they may fortify their value propositions with proprietary, non-interoperable devices and solutions.

Finally, a solutions provider platform offers a yet more integrated offering, including horizontal solutions such as AI and data analytics capabilities, while integrating some use case-specific hardware (e.g. sensors, robotics or drones) in the platform's own retail marketplace. Further, it builds expertise from being itself an early user of some 5G-enabled use cases. It has also the ability to better cross subsidize, i.e. providing services to one side within the platform, at a reduced cost or for free, at the expense of another, more profitable side, in order to foster the growth of the earlier. In sum, these platforms intend to be the portal where everything can be found at the lowest price and in a highly personalized manner; they reach beyond telecommunications, further enhancing network effects.

F. Location- or purpose-specific (e.g. smart city) ecosystems

The final business model we propose addresses complex ecosystems where specific services are provided within their physical boundaries (e.g. a smart city or a highway). From an economics perspective, a differentiated model for it makes sense if: (i) there is a natural monopoly from the size of the investment or there are other specific barriers to entry (e.g. the cost of rolling out a dense network of small cells in a city); (ii) there exist positive externalities from the deployment of the network and the enabled applications; or if (iii) it is considerably difficulty by a traditional CSP to gain customer ownership (e.g. when there are complementary assets to which customers attach more of the value from their experience). These could cause the market to undersupply at an equilibrium level, resulting in a suboptimal outcome in terms of welfare. This may lead to the appearance of a large player that pools demand and takes the role of CSP, being it a governmental authority, a (subsidised or licensed) organization, or a specific-purpose entity that makes sure the required investments are undertaken and the valuable services supplied. In the context of smart cities, municipalities may decide to lead investment in physical infrastructure or provide connectivity for free or at subsidized prices to its citizens, understanding it as a utility. Monetization strategies can include charging directly for the service, levying fees on the sales of the firms within the ecosystem (e.g. shop owners or car manufacturers), or financing it through taxes and governmental budgets. A possible arrangement could be assigning local spectrum licenses to cities, for them to delegate and subsidize the deployment of infrastructure and the lifecycle management of slices to private operators, in an on-demand basis. The public entity could appear as the specific-purpose CSP, being the one who visibly delivers value to end users. Furthermore, they could subsidize local joint ventures or partner with the private sector to incentivise those use cases deemed as most socially valuable.

Instances involving positive externalities would exist if CSPs were not able to monetize the overall ecosystem benefits that arise from enabling certain use cases. More concretely, smart cities and connected driving can yield safety and transportation benefits, reduced environmental footprint, etc.; in general, higher quality of life for citizens. However, oftentimes customer demand does not price in these benefits, as customers may not be willing to pay the premiums that the required investments would entail. For example, in a highway scenario like the one described in [31], where there are different dedicated slices for different services (namely autonomous driving and infotainment), if connectivity is constantly available and ubiquitous for all connected cars, the slices could behave as non-excludable goods, and some end users would not feel the need or utility to pay for it, while car makers could see it as decoupled from their products. Therefore, it would be challenging for CSPs to monetise the service, threatening the sustainability of it and the indirect benefits enjoyed collectively.

In addition, to valorise the ever larger amounts of data that the IoT will generate, such governmental entities can also nurture the creation of trusts and initiatives to incentivise data sharing and the improvement of security and ethical practices.

IV. Discussion & Conclusions

5G and network slicing enhance value propositions through performance, cost efficiency and personalisation improvements, and enable advanced revenue models. In addition, these technologies indirectly impact business models and competition by increasing the relevance of different complementary assets that affect the distribution of control within value chains. Further, they bring complexity to the competitive environment: 5G ecosystems will encompass multiple industries, and B2B models will become more relevant. Moreover, cost pressures may increase network sharing, which in turn would push competition upwards to higher layers, where many players compete at different fronts.

This paper described six feasible business model types for the expected future competitive environments. The resulting models will be contingent on the economic characteristics of a specific site or environment. In certain settings, such as critical infrastructure sites, a micro operator may play a powerful and profitable connectivity-provider role, while in others, like smart cities, a special-purpose entity may take a central role to enable 5G services. Notwithstanding, in both these cases an MNO would still adopt one of the business models presented in Table 1. Pervasive, non-operator platforms may increase their power over the telecommunications industry, due to their ownership of valuable complementary assets. Consequently, MNOs risk becoming mere service providers. On the contrary, operators could take a ubiquitous role through a centralised platform or by orchestrating a decentralised ecosystem.

MNO role	Key assets	Market power	Main competitor & source of competition
XaaS	Spectrum	Low	μOs and MNOs, up- and down-stream
Use case enabler	Spectrum, customer data	High within vertical; uncertain in overall CSP market	Other MNOs, horizontally
Orchestrator	Spectrum, customer data, financial robustness	Low within ecosystem layers; high among MNOs	Intra-ecosystem, contingent on its non-orchestrating offer
Integrated platform	Spectrum, customer data, financial robustness, OTT content	High	Potential (tech or MNO) platforms, at different verticals

Table 1. 5G MNO-central business models and competitive outcome

Policy actions can be taken to encourage certain business models in order to address potential issues such as market failure (see section III.F), a lack of competition (III.E), safety (III.A), or to foster the quick rollout of networks for the positive externalities they bring (III.B, III.C, III.D), an objective highlighted by the European Commission in the new Electronic Communications Code. Regarding spectrum policy, the analysis in this paper is limited by the assumption that operators will control the licenses of 5G spectrum. Finally, further research could extend the present analysis by investigating what factors, beyond business choices, may drive and shape the future business models and ecosystems.

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