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Benefiting from Innovation in Future 6G

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To succeed, planning is insufficient. One must improvise as well.
(Isaac Asimov)

Benefiting from Innovation and General-Purpose Technologies

The profiting from innovation (PFI) framework (Teece, 1986) has widely been used to explain value capture from innovation. It explicates gaining full potential and capturing value from technological innovation (e.g., mobile communications industry) by innovators who utilize intellectual property protection provided by regulators (e.g. patents),

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inimitability afforded by the tacit nature of knowledge, and access to relevant complementary assets such as delivery channels.

However, considering the depth of the changes characterizing the contemporary innovation environment, the original PFI framework may have limited applicability and hence call for adjustment. As Gambardella et al. (2021, p. 75) suggest "*at least one important category of technology (i.e., enabling technologies) will not fit comfortably*" in the original PFI framework which is more coherent for explaining value capture from discrete inventions, such as the fourth-generation (4G) mobile communications technology providing connectivity to its users, with relatively narrow down-stream applicability (Kapoor & Teece, 2021). Enabling technologies are considered "*upgradable, adaptable technologies with improvement potential that have broad applicability which affects how returns accumulate from them*" (Gambardella et al., 2021, p. 75), like those emerging in the fifth generation of mobile communication technology (5G). Similar challenges are connected to general-purpose technologies (GPT), that is, technology characterized by general applicability (pervasiveness) across a variety of fields, technological dynamism, and innovation complementarities (Bresnahan & Trajtenberg, 1995). Examples of GPT have been noted to include steam power, electricity, the Internet, laser technology, and nanotechnology, as well as artificial intelligence (AI) (Yang et al., 2022), or 6G (Yrjölä et al. 2022).

To summarize the key differences between discrete, enabling, and general-purpose technologies and to link them with past, current, and

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future mobile communications generations of 4G, 5G, and 6G, respectively, the following characterization is provided:

- Discrete technological solutions of 4G—innovation at the firm level—collaboration on the supply side—competition in the highly regulated demand (i.e., connectivity service) side.
- Enabling technologies of 5G—innovation at the ecosystem level—collaboration on both supply and demand sides—competition in the highly regulated demand side.
- General-purpose technology platforms/infrastructures of 6G—innovation at the ecosystem level between countries—collaboration and complementarities on both supply and demand sides—competition converging in multi-platform ecosystems comprising connectivity, data, and cloud platforms.

As the convergence of wireless and Internet technologies between industries proceeds and innovation increasingly takes place on platforms and in ecosystems driving the sixth generation of mobile communication networks (6G), the logic of gaining returns from innovative activities will also change. Importantly, the 6G context will be characterized by a completely new kind of convergence and new complementarities and there will be a central role for general-purpose technologies, which will generate new needs to understand how value can be captured from innovation. We propose here, following recent theorizing on innovation appropriability and appropriation (see, e.g., Gambardella et al., 2021), that instead of profiting from innovation, attention will turn to *benefiting from innovation*. We suggest that for 6G, a shift from the PFI approach to benefiting from innovation approach with interactive appropriability—i.e., "*context-specific dynamic aligning of appropriability premises (constituted with appropriability mechanisms and complementary assets) and interacting with other agents by relying on exclusion of others, leveraging the appropriability premises, and abandoning of protection, to benefit from innovation and appropriate value*" (Yang & Hurmelinna-Laukkanen, 2022, p. 311)—is relevant.

Building on the above discussion, we apply a general conceptual framework for innovation appropriability and appropriation. This

framing provides a means for addressing the specificities of benefiting from innovation in the 6G context. Figure 7.1 provides an overview of the general logic of the approach.

The profiting from innovation framework looks especially into the logic of how innovators can monetize their innovation with the help of the so-called appropriability regime covering legal instruments (especially intellectual property rights, IPRs) and the (tacit, hard-to-imitate) nature of the technology, as well as *complementary assets* that give them bargaining power in the markets (Teece, 1986, 1998). Benefiting from innovation, however, requires a wider view. It considers not only a variety of appropriability mechanisms and complementary assets, but also how these instruments are utilized. It further addresses how such appropriability premises and their uses are aligned with(in) the contextual and situational factors surrounding them (Hurmelinna-Laukkanen & Yang, 2022; Yang et al., 2022). Likewise, this view explicitly acknowledges that the appropriation outcomes may not be only about the immediate profits from innovation (see Ahuja et al., 2013, about primary appropriability), but the benefits may be quite varied from private to social returns, and they may accrue over time. These elements are central components of the *interactive appropriability* (Yang & Hurmelinna-Laukkanen, 2022) that embraces the dynamism and investigates the alignment of the appropriability-enhancing *instruments*, the *processes* in which they are used, influential contextual factors, and appropriation *outcomes*, as depicted in Fig. 7.1.

Applying the Benefiting from Innovation Framework to 6G

6G—which can be considered an emerging general-purpose platform—will transform how and what kinds of services are offered, responding simultaneously to increasing societal demands for resilience, sustainability, inclusion, and empowerment (Yrjölä et al., 2022). This means that the dimensions of appropriability and appropriation will have their own specific nature in this context.

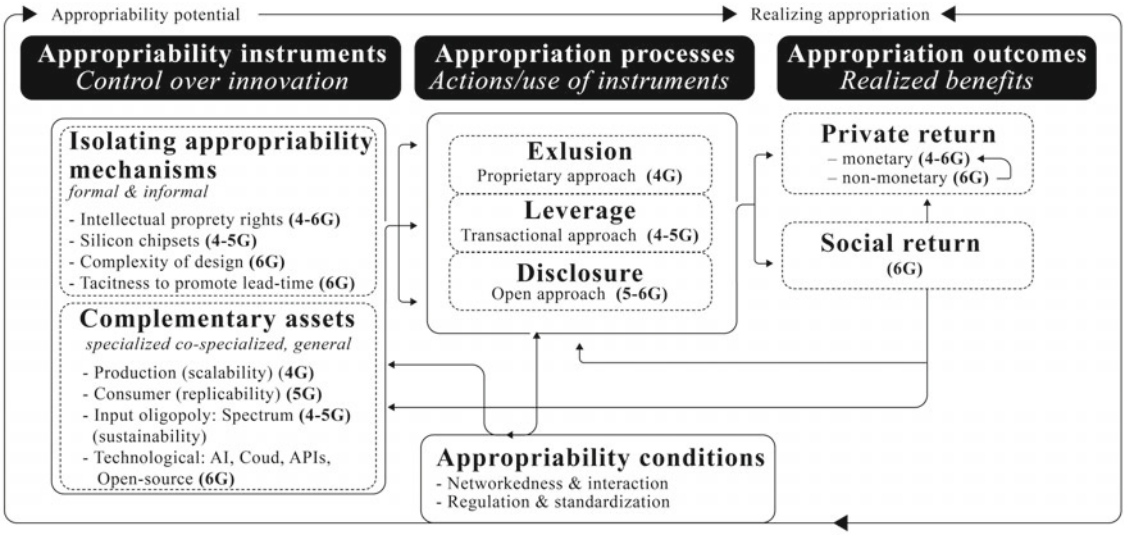

Fig. 7.1 Benefiting from innovation in a 6G context framework with a comparison to 4G and 5G (*Source* Hurmelinna-Laukkanen and Yang, [2022])

Appropriability Mechanisms and Complementary Assets

First, in the 6G context, isolating appropriability mechanisms and complementary assets for GPT may well be the same as those for more discrete technologies or in other innovation contexts. Intellectual property rights (IPRs), contracts, tacitness, lead time, and human resources-related *isolating appropriability mechanisms* may be utilized, and brand and sales assets may be acquired as relevant complementary assets to support value capturing (see Hurmelinna-Laukkanen & Puumalainen, 2007). However, these may be affected by the appropriability conditions, which makes the selection of appropriability mechanisms and complementary assets in 6G context more complex and may influence the emphasis given to individual instruments.

In fact, certain shifts can be observed regarding the selection of appropriability mechanisms. In 4G (and 5G), relying on IPRs was the norm, and complementary assets such as access to distribution channels or marketing capabilities were highlighted. Complexity and high external transaction costs drove mobile network operators to own and operate network assets, especially spectrum, radios, tower, backhaul, data centers, computers, storage, and transport. At present, the Internet and information technologies, coupled with financial and supply chain sophistication, enable mobile operators to exploit assets owned by others such as towers, cloud data centers, computing and storage resources, which has already turned attention to the role of consumers and replicability as well as input oligopoly, for example, as complementary assets that emerge as opportunities (and varying tensions) in the networked settings where the selection of the appropriability instruments calls for careful attention (see Hurmelinna-Laukkanen & Nätti, 2012; Stefan et al., 2021).

The future decentralized 6G, especially with Web3 blockchain and smart contracts, is expected to dramatically lower the cost of external (market) transactions which will encourage further disaggregation to maximize business agility, improve resource utilization, and better align business risks and rewards. Standards in this area and various regulatory requirements for maintaining market competition, handling data, and

ensuring security, for example, will influence how firms can and need to approach appropriability instruments. Business and regulatory restrictions may constrain value appropriation from downstream sectors (Yrjölä et al., 2022). In addition to telecommunications regulations and related competition laws, challenges arise from information technology regulation and industry segment-specific regulations. For example, the network neutrality principle may constrain value capture in providing the long-tailed distribution of differentiated future services (Frias & Martínez, 2018). Critical issues in 6G will be regulation related to multi-sided digital cloud platforms and the governance of the privacy and security of users, especially affecting the data protection and artificial intelligence rights. Furthermore, technological innovations may require access to new technological public or semi-public *complementary assets* such as the authorization of the radio spectrum, access regulation of the obligations for interoperability, and the use of public infrastructure (Yrjölä et al., 2022).

Spectrum authorizations, including administrative allocation, market-based mechanisms, and the unlicensed commons approach, will play a key role in defining the wireless markets and ultimately defining who can operate various wireless systems (Matinmikko-Blue et al., 2020). Timely access to affordable quality spectrum resources will be fundamental in allowing new market entry for innovative wireless solutions and a powerful tool for incentivizing and forcing different spectrum users to act toward sustainability goals desired by the national regulators (EC RSPG21-027, 2021). In fact, a relevant complementary asset could be seen to stem from the need to have suitable knowledge assets to handle these demands; access to (or even ownership of) regulatory and standardization related knowledge is increasingly important.

Exclusion, Leverage, and Disclosure

Second, the 6G context will be inherently characterized by open innovation logic, which will directly influence the appropriation processes. Whereas 4G can be considered to have been focused on exclusion and proprietary strategies of the central players, the business models discussed

in the 5G literature highlight more connectivity service provisioning and its differentiation (Yrjölä et al., 2022), which reflects an increasing reliance on leverage processes (Fig. 7.1).

6G, on the other hand, has been envisioned as an intelligent system of systems that will converge connectivity with complementary services such as imaging, sensing, and location, opening numerous new application areas and business opportunities (Latva-aho & Leppänen, 2019). The emerging 6G business ecosystems will be characterized with novel resource configurations and changing and novel stakeholder roles such as local operators, cloud operators, infrastructure providers, and resource brokers. The openness of business models boils down to discussions on open innovation (Chesbrough, 2003, 2006), and in platform contexts, this brings the ecosystem and its stakeholders close. For example, a software-based, service-oriented cloud-native 6G network could enable efficient infrastructure and resource sharing by different tenants, and could open the ecosystem to new players, and accelerate the time to market by reducing service creation and activation times.

Modularization and open interfaces facilitate competition and entry, enabling stakeholders to specialize within the ecosystem and develop complements to the platform. Consequently, start-ups can increasingly access complementary assets through various forms of alliance with larger firms. Thus, 6G as a GPT may have large positive innovation spillovers and externalities, both stable and dynamic, that alter the valuation of existing technologies and enable opportunities for third-party and novel stakeholders (Carlaw & Lipsey, 2002). Against this setting, the appropriation processes are highlighted; actors need to be highly selective in terms of exclusion, leverage, and disclosure-oriented approaches (see Hurmelinna-Laukkanen & Yang, 2022). Employing the full range of alternative appropriability instruments (isolating appropriability mechanisms and complementary assets) is likely to be needed in the 6G context, where situations may change quickly. Especially for GPT, openness may be imperative in the search for best use cases (Yang et al., 2022), but this does not imply that no benefit could be gained by keeping some elements away from the reach of others. For example, while modular architecture with open interface specifications will enable the majority of software functions to be deployed on any

commercial computing hardware, lower-layer processing-intensive radio functions may continue to be implemented in custom silicon chipsets with proprietary technological innovations.

Private and Social Returns

Finally, it needs to be acknowledged that the wanted (and pursued) outcomes matter already at the stage of strategizing on and building of appropriability premises. While the original PFI framework considers private return to the innovator to be an integral incentivizing factor (Teece, 1986, 1998), the changes brought by technological developments and shifts toward platform and ecosystem-based approaches have augmented the view to include appropriation outcomes (Hurmelinna-Laukkanen & Yang, 2022). In the 6G context, these aspects have increased their importance. Appropriability may include the appropriation of social value (at different levels from self-reward for individuals to wide benefits that match the United Nations Sustainable Development Goals (SDGs)), which could be highly relevant in contemporary innovation environments where sustainability and other such aspects have increased in importance. 6G is no exception to this, and mobile communication networks, increasingly underpinning mission-critical functions across communities and businesses after 2030, will not only transform how and what kind of services are offered; they will also be shaped by the growing societal requirements of resilience, inclusion, sustainability, and empowerment (Yrjölä et al., 2022).

Social value is not necessarily where the benefit from innovation ends. In Fig. 7.1, the arrows from social return to private return illustrate this. Alnuaimi and George (2016) have noted that knowledge retrieval can benefit original innovators later even if they release (or lose) the inventive technologies to the surrounding environment where others exploit it. Spillovers and social returns may become a source of private returns for the initial innovator especially in case of GPT (see Yang et al., 2022). In the 6G context, this could happen via increased use of as-a-service (aaS) business models where resources and infrastructure are not purchased, but consumed as a service (Matinmikko et al., 2021). For example,

serverless cloud application development and execution models will allow developers to build and run code and applications without managing servers, and without paying for idle cloud infrastructure.

Conclusions and Implications

The above discussion suggests that interactive appropriability (Yang & Hurmelinna-Laukkanen, 2022)—resonating with value co-capture within the 6G ecosystem—will be highly relevant in order to benefit from innovation in the 6G context. In particular, it advocates the relevant players to combine firm- and network-points of view in a meaningful way. Innovators can and need to carefully align their selection of appropriability instruments with the prevailing conditions—paying specific attention to the regulatory and other such requirements, and the networked context in which they operate (see Hurmelinna-Laukkanen & Nätti, 2012). At the same time, they need to align the use of those instruments with the pursued appropriation outcomes. Importantly, the relatively more notable role of social returns compared to private returns requires acceptance of uncertainty, instead of immediate private return. At the societal level, the largest rewards for 6G as a GPT may come from later, yet unforeseeable activity. In the 6G context, some examples, and signals of this are already visible, exemplified by the opportunity to strengthen prosumerism and human-centricity via digital inclusion and rural mobile communications. As a part of its enabling role, 6G will help different sectors of society to monitor and renew sustainable operations via solutions and services combining communication with other services such as imaging, sensing, and locating, with hyper-local granularity.

It appears evident that 6G will co-exist with several generations of mobile communications technologies, which indicates of the importance of backward compatibility, continuity toward 7G, and complementarities between technology domains over the evolution of the generations. To date, this evolutionary development has followed the define-standardize-develop/deploy-use cycle of technology commercialization (Ahokangas et al., 2023). The benefit from an innovation framework embracing the logic of interactive appropriability, therefore, has direct

implications for innovation policies applied to developing 6G as a GPT, as well as implications for regulatory authorities framing future 6G, and firms and entrepreneurs aiming at commercializing 6G.

Implications for Innovation Policy

Currently, global competition to define future 6G has begun. Digital technologies in general have become the "*battleground for the competition for global leadership*" (Moerel & Timmers, 2021, p. 5). This can be seen in the launches of national 6G research and innovation programs, and the collaboration between countries, for example, at the European level. As innovation policies have direct and indirect impacts on a firm's innovation practices and intellectual property creation, in the case of GPTs, international cross-industry innovation sets new demands for integrated, transformative, and directed innovation policies based on a shared vision of what 6G could become. To allow innovators to benefit from 6G innovation, the specific attention of the innovation policies should, on the one hand, be targeted to create a favorable environment for appropriability instruments, i.e., isolating mechanisms and complementary assets, to work, especially in AI. On the other hand, innovation policies should pay attention to social returns and spillover effects on upstream and downstream industries and the society at large. Transformative innovation policies (TIPs) may help developing converging and complementary new technologies (Bailey et al., 2019). A TIP in the context of 6G as a GPT could mean an innovation policy based on vision-based directed innovation, a twin focus on covering market imperfections and failures, and new emerging opportunities for complementarities and creating a competitive edge and new markets.

Implications for Regulatory Authorities

In today's mobile communications context, the national regulatory authorities define rules of the business by allowing, limiting, or directing what kind of activities are possible for the ecosystem stakeholders. Traditionally, the regulators' key concern has been to ensure competition and

innovation in the markets, depending on the local market conditions and available technologies. However, given the increasingly complex regulatory domain affecting the development, deployment, and use of 5G and future 6G, regulatory authorities would be advised to consider the appropriability conditions emerging for 6G to maximize the national potential for appropriability in both 5G and 6G. A good question is what the compound impact of regulations on the appropriability of 6G will be. Although the appropriation outcomes, private and social rents, have been of interest for regulators, it is also expected that the role of societal rents and implications are becoming central in the 6G context, especially due to the increasing role of AI for 6G. It already is a fact that global 5G and 6G will be facing different regulatory logics combined with varying innovation policies and market approaches. The market-based US, the rights-based European, and China's government push-based logic in developing new technologies will have an impact on how these technologies generate private and societal rents for different firms and societies (Feijóo et al., 2020).

Implications for Firms and Entrepreneurs

Finally, the benefiting from innovation framework can be highly valuable for firms attempting to benefit from 6G innovation. For incumbent firms, the changing role of innovation and ecosystems will mean the need to develop new ecosystem-embracing strategies and business models in their existing markets. The incumbents should pay attention to emerging new ecosystems and business verticals in the intersection of different technological domains, considering the relevance of interactive appropriability. Similarly, start-ups and small and medium-sized enterprises should explore growth opportunities with complementary services in emerging 5G and 6G ecosystems from this perspective; while smaller firms tend to focus on immediate financial return for obvious reasons, they also need to be aware of the search for varying appropriation outcomes in the ecosystems around them. The discussed framework shows how appropriability instruments may be available to all firms, but that the readiness to engage in varying appropriation processes may

open new insights leading to benefits from innovation in the emerging GPTs—also other than 6G.

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